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Volume 20

CONTENTS

ARTICLES

BOOK REVIEWS

*Acta Botanica Academiae Scientiarum Hungaricae, Vol. 28 (1–2), pp. 1–14 (1982)*

# XYLOTOMIC EXAMINATION OF SOME VENEZUELAN *CAPPARIS* SPECIES, II

K. BABOS[1]

[1] RESEARCH INSTITUTE FOR THE WOOD INDUSTRY, BUDAPEST, HUNGARY

I. R. BERMUDEZ[2] and C. L. J. CUMANA[2]

[2] BIOLOGICAL DEPARTMENT OF SCIENCE UNIVERSITY OF ORIENTE, CUMANA, VENEZUELA

(Received: 1 September 1981)

The exterior morphological, eclogical characteristics, habitat, moreover the main anatomical features of the xylem of the following four Venezuelan *Capparis* species are described: *Capparis sessilis* Banks. ex DC., *C. pachaca* H. B. et K., *C. odoratissima* Jacq., *C. stenosepala* Urb.

## Materials and methods

The blocks made from the wood of diverse *Capparis* species were softened in a BRINZER's autoclave in 1 : 1 mixture of water and glycerine, at 1.5–2 atm. After the maceration, transversal, tangential and radial sections were prepared. The sections were dyed with the alcoholic solution of toluidin blue. The maceration of tissue was made with the Schulze-method (SÁRKÁNY and SZALAI 1964).

Length of fibres and vessel-elements, tangential and radial diameters of vessels, width and height of medullary rays and other characteristics were measured. The minima-maxima values of the anatomical features of each *Capparis* species were calculated from 50–100 measurements. Enlarged microphotographs were made on each section.

## External morphology and distribution

On the basis of a description made by Prof. ISIDRO R. BERMUDEZ and LUIS J. CUMANA C. (BERMUDEZ and CUMANA, 1980).

To the present paper will be enclosed the photographs of vegetation and habitat of some *Capparis* species described in the first part (Figs 17–20) and those of the *Capparis* species described in the present part (Figs 1–3).

### *Capparis sessilis* Banks. ex DC.

Shrub 0.5–2.5 m high. Tomentose stem. Alternate, obovate leaves, blades 1.5–9 cm long, mucronated apex, tomentose, concolorous. Racemose inflorescence, terminal, 2.5 cm long. Hermaphrodite, actinomorphic flowers, 2–5 cm long. Calyx with 4 sepals, superposed, two of them 5–7 cm long, two 4–5 cm long, tomentose, light green. Corolla with 4 contorted petals, 1–7 cm long, white. Numerous stamina (66–78), 2.8–3 cm long, anthers bitheca, 2–3 mm long, longitudinal dehiscence. Ovary above a gynophore 2.8–4 cm long; bicarpel, unilocular; pseudo-septum is present. Numerous ovules, parietal placentation, sessile stigma.

Bacciform, elongated, sub-cylindrical fruit capsule, dehiscent, 6.5–23 cm long, glabrous, bright coloured, purple-reddish sutures are present.

Habitat: in dry, gravillous, sandy, oligotrophic soils. They grow scattered on the roadside, in shady or intensively lightened places. They are not very frequent.

Distribution: State of Sucre, Esparta.

### *Capparis pachaca* H. B. et K. (Fig. 1)

Tree of 3–6 m height. Glabrous stem. Alternate, elliptical, lanceolate leaves. Lamina 2–15 cm long, with marginated, mucronated apex; glabrous, coriaceous; adaxial and abaxial surfaces olivaceous. Racemose inflorescence, terminal, 1.5–8 cm long. Calyx with 4 valvate sepals 2–3 mm long, glabrous, yellowish, glands present. Gamosepalous. Corolla with 4 petals, contorted, white, 1–1.5 cm long. Numerous stamina (52–62), 2–3 cm long; anthers bitheca, 3–4 mm long, longitudinal dehiscence. Ovary above a gynophore 3–4 cm long, bicarpel, unilocular; pseudo-septum is present; numerous ovules, parietal placentation, sessile stigma. Bacciforme, globose-sub-spheric fruit capsule, indehiscent, 6–7 cm long, rugose, divaceous.

Habitat: in dry, gravillous, sandy, oligotrophic soils, isolatedly or in small groups on the roadsides or on the hills intensively exposed to light. They are not very frequent.

Distribution: State of Sucre, Esparta.

### *Capparis odoratissima* Jacq. (Fig. 2)

Tree or shrub of 2–7 m in height. Lepidopterous stem. Alternate, elliptical lanceolate leaves. Lamina 1.3–1.5 cm long, obtuse, mucous; adaxial surface glabrous, olivaceous, lustrous, abaxial surface pale green. Racemose inflorescence, terminal, 0.9–5 cm long. Hermaphrodite, actinomorphic flowers 1–1.5 cm long. Calyx with 4 sepals, superposed, yellowish, 3–5 mm long, glandulae are present. Corolla with 4 petals; contorted, lepidopterous petals 5–6 mm long, white when young, and purple-reddish when matured. Numerous stamina (24–32) 5–6 cm long. Anthers bitheca, 1–2 mm long, longitudinal dehiscence. Inferior ovary, elongated, bicarpelar, unilocular, with pseudo-septum. Numerous ovules, parietal placentation, sessile stigma. Bacciforme, oval, cylindrical, elongated, sub-torulose, dehiscent fruit capsule, 1.5–15 cm long, chestnut-brown-yellowish, rough, squamous.

Habitat: in dry, gravillous, sandy oligotrophic soils, scattered or in small groups on the roadsides and hills intensively exposed to light. They are frequent.

Distribution: in Sucre and in other States, Nva. Esparta, Carabobo, Zulia, Lara, Anozotegui, Falcón, Dtt. Federal.

### *Capparis stenosepala* Urb. (Fig. 3)

Tree or shrub of 1.5–3 m in height. Stem covered with trichome. Alternate leaves, ovate or elongated lanceolate. Lamina 1–30 cm long, with mucronated apex; coriaceous. Racemose inflorescence, terminal, 3–10 cm long. Flowers are hermaphrodite or, because of atrophy of the stigma are masculine, 3–6 cm long. Calyx with 4 dialisepals, valved, green. Corolla with 4 dialipetals, yellow, 1.5–2 cm long. Few stamina (6–9), 2–3 cm long. Anther bitheca, 3–4 cm long; longitudinal dehiscence. Bicarpelar, unilocular ovary above a gynophore, with numerous ovules; parietal placentation, sessile stigma. Bacciforme, spheric fruit capsule, indehiscent, 7–8 cm long, rugose, green-yellowish.

Habitat: in dry, shallow oligotrophic soils on the shady roadsides, scattered. They are very frequent.

Distribution: State of Sucre, Esparta.

*Fig. 1. Capparis pachaca* H. B. et K., flowering branch. Photo: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28

*Fig. 2. Capparis odoratissima* Jacq., flowering branch. Photo: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28

*Fig. 3. Capparis stenosepala* Urb., tree, habitat. Photo and collector: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28
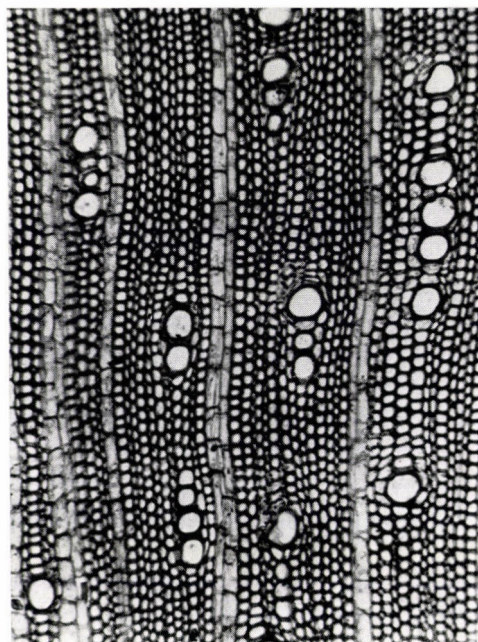
*Fig. 4. Capparis sessilis* Banks. ex DC. Cross-section enlarged 120 times. Small sized vessels, vessel groups, medullary rays and fibres. Contact vasicentric longitudinal parenchyma

## Wood Anatomy

In this paper the basic work of METCALFE and CHALK (1950) was firstly considered.

### *Capparis sessilis* Banks. ex DC.

Diffused porous wood. The basic mass of wood is formed by polygonal-shaped fibres with thinner wall and wider lumen. Paratracheal and contact vasicentric longitudinal parenchyma. Medullary rays with one or more cells wide (Fig. 4).

Roundish or oval-shaped tracheae, tangentially flattened within the groups (2–10 members); within the Capparis species sizes are relatively small; rarely with gum material. 32–43–70 tracheae per mm$^2$. Tangential diameter 20.70–47.10–57.50 $\mu$m. Radial diameter 20.70–40.94–59.80 $\mu$m. Length of the vessel-members 119.60–155.94–211.60 $\mu$m; small, alternate, elongated bordered pits on their wall. Simple perforate plate.

Medullary rays up to 1–2, not rarely 3–4 cells wide, with homogeneous or heterogeneous structure. Height 34.50–209.07–437.00 $\mu$m. Width up to 11.50–32.66–57.50 $\mu$m. Ray cells frequently contain gum (Figs 5, 6).

Fibres are arranged in radial rows. Diameter 7.80–13.41–17.16 $\mu$m. Wall thickness 1.56–1.73–3.12 $\mu$m. Full length 142.0–297.5–426.0 $\mu$m. Tip of the fibres ending in a point.

Diameter of the longitudinal parenchyma cells 9.20–14.03–23.00 $\mu$m. Height 27.60–57.59–138.00 $\mu$m. The cells rarely contain gum.

*Fig. 5. Capparis sessilis* Banks. ex DC. Tangential section enlarged 120 times. Medullary rays 1, 2, 3 cells wide, fibres with thick wall. Vessel and longitudinal parenchyma
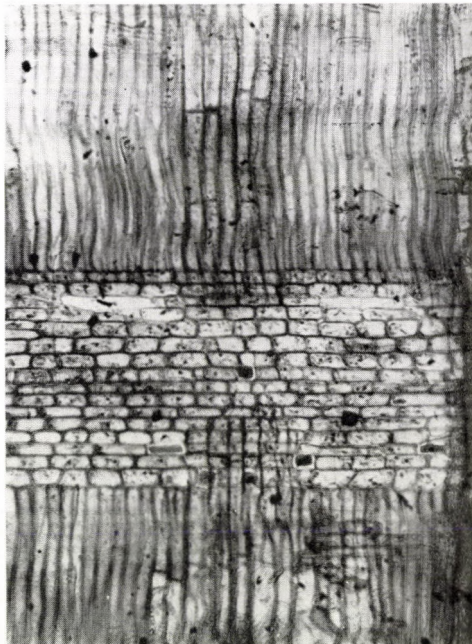
*Fig. 6. Capparis sessilis* Banks. ex DC. Radial section enlarged 120 times. Heterogeneous medullary ray, vessel-like tracheids, longitudinal parenchyma, fibres with thin wall. Dark gum in the medullary ray cells
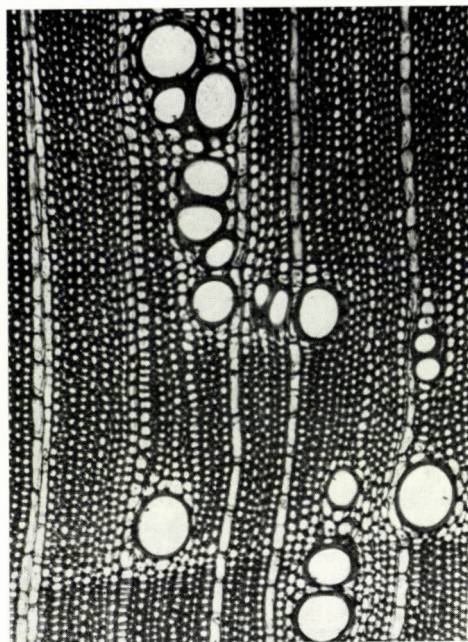
*Fig. 7. Capparis pachaca* H. B. et K. Cross-section enlarged 120 times. Vessels, vessel groups with small sized vessel-like tracheids, medullary rays and fibres. Contact vasicentric longitudinal parenchyma

*Fig. 8. Capparis pachaca* H. B. et K. Tangential section enlarged 120 times. Medullary rays 1–2 cells wide, vessel and vessel-like tracheid, longitudinal parenchyma, fibres with thicker wall
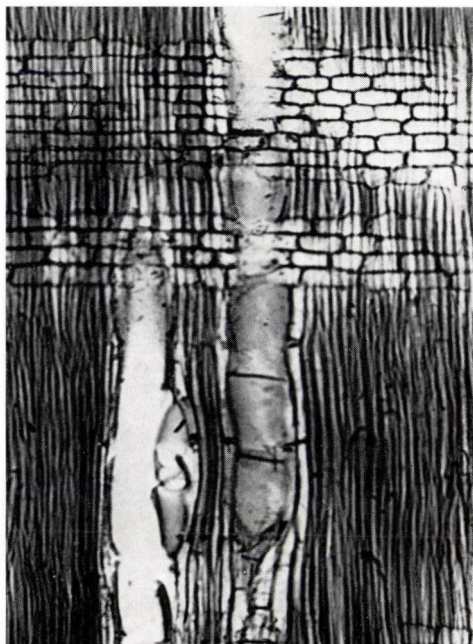
*Fig. 9. Capparis pachaca* H. B. et K. Radial section enlarged 120 times. Heterogeneous medullary rays, vessels longitudinal parenchyma and fibres
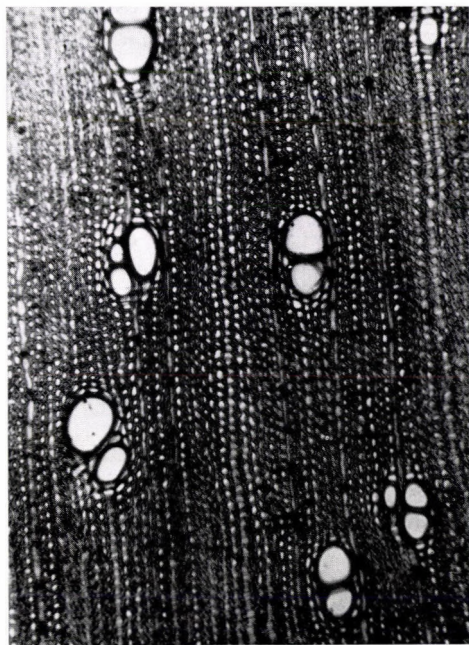
*Fig. 10. Capparis odoratissima* Jacq. Cross-section 120 times. Smaller sized vessels and vessel groups, medullary rays, fibres with thicker wall. Contact vasicentric longitudinal parenchyma
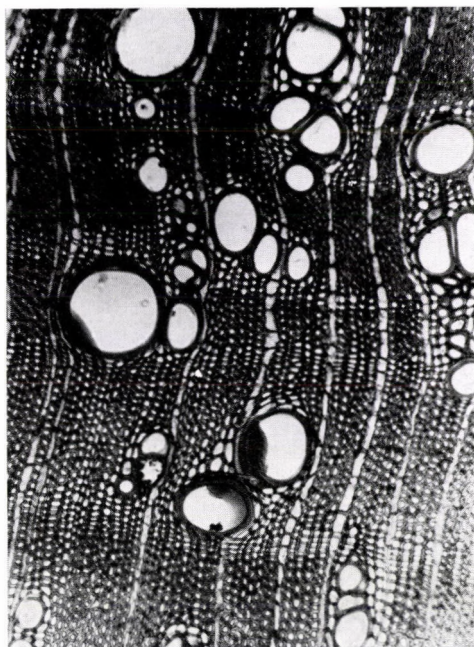
*Fig. 11. Capparis odoratissima* Jacq. Cross-section enlarged 120 times. Large sized vessels, vessel groups and small sized vessel-like tracheids. Dark gum in the vessels. Medullary rays and fibres with thick wall. In addition to the contact vasicentric longitudinal parenchyma, there is an aliform-confluent longitudinal parenchyma, too

## *Capparis pachaca* H. B. et K.

Diffused-porous wood. The basic mass of wood is formed by fibres with thicker wall and medium lumen. Paratracheal, contact vasicentric longitudinal parenchyma. Medullary rays up to 1–2, rarely 3 cells wide (Fig. 7).

Roundish or oval shaped tracheae, tangentially flattened within the groups (2–12 members). Their number up to 15–23–34 per mm$^2$. Tangential diameter 25.30–51.58–78.20 μm. Radial diameter 29.60–60.16–89.70 μm. Length of the vessel members up to 110.40–160.63–220.80 μm; alternate, small elongated bordered pits on their wall. Simple perforate plate.

Medullary rays up to 1–2, rarely 3 cells wide, with homogeneous or heterogeneous structure. Height 46.00–226.09–540.50 μm. Width 11.50–39.90–57.50 μm (Figs 8–9).

Fibres are arranged in radial rows. Diameter 6.24–10.51–14.04 μm. Wall thickness 1.56–2.49–3.12 μm. Full length up to 284.0–416.1–639.0 μm. Tip of fibres ending in a point.

Diameter of longitudinal parenchyma cells up to 27.60–49.49–95.60 μm.

## *Capparis odoratissima* Jacq.

Diffused-porous wood. The basic mass of wood is formed by polygonal-shaped fibres with thinner wall and narrower lumen. Paratracheal, contact vasicentric, rarely aliform-confluent longitudinal parenchyma.
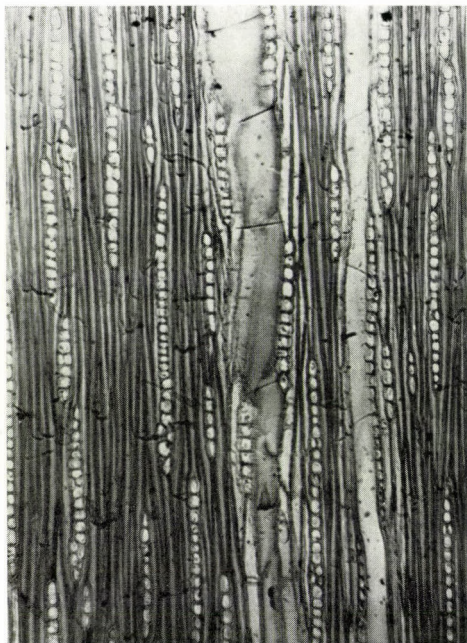
*Fig. 12. Capparis odoratissima* Jacq. Tangential section enlarged 120 times. Medullary rays 1 and 2 cells wide; vessel, vessel-like tracheid; longitudinal parenchyma and fibres
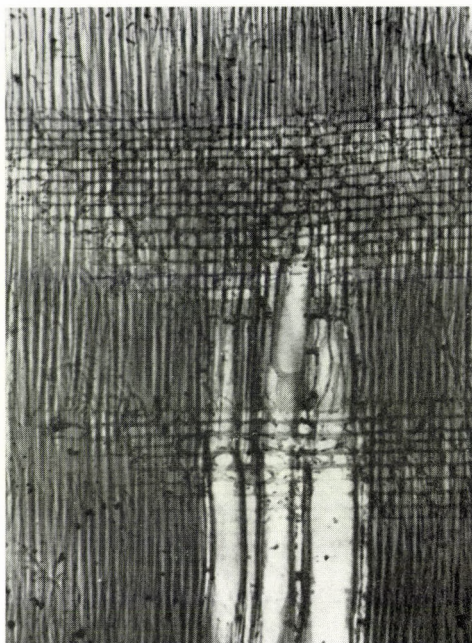
*Fig. 13. Capparis odoratissima* Jacq. Radial section enlarged 120 times. Heterogeneous medullary rays, vessel and longitudinal parenchyma, fibres with thick wall
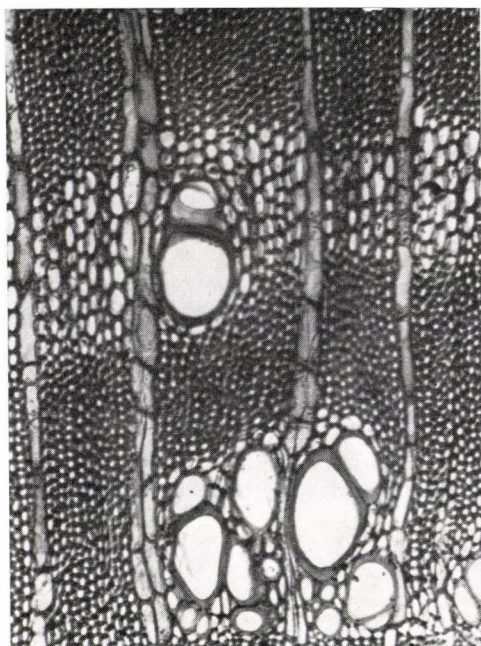
*Fig. 14. Capparis stenosepala* Urb. Cross-section enlarged 120 times. Vessels, vessel groups, small sized vessel-like tracheids in the vessel groups. Medullary rays, fibres with thick wall. Aliform-confluent longitudinal parenchyma

*Fig. 15. Capparis stenosepala* Urb. Tangential section enlarged 120 times. Medullary rays 1, 2 and 3 cells wide. Vessels, longitudinal parenchyma and fibres with thicker wall
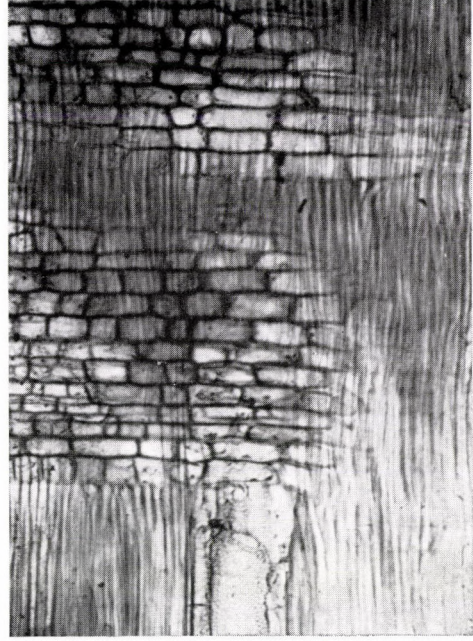
*Fig. 16. Capparis stenosepala* Urb. Radial section enlarged 120 times. Heterogeneous medullary rays, vessel, longitudinal parenchyma and fibres

*Fig. 17. Capparis coccolobifolia* Mart. ex Eich., flowering branch. Photo: I. Bermudez and L. Cumana, Tacal-Edo. Sucre, 1980. III. 28

*Fig. 18. Capparis indica* Druce., flowering branch. Photo: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28

*Fig. 19. Capparis linearis* Jacq., shrub, habitat. Photo and collector: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28

*Fig. 20. Capparis linearis* Jacq., flowering branch. Photo: I. BERMUDEZ and L. CUMANA, Tacal-Edo. Sucre, 1980. III. 28

Medullary rays up to 1–2, rarely 3 cells wide (Figs 10 and 11).

Roundish or oval-shaped tracheae, rarely solitary. Within the vessel groups (2–4 members) there are small tracheid-like vessels, too. Size of the vessels is generally not large, but there are some vessels 2- or 3-times larger than the medium size. Their number 26–31.4–40 per mm$^2$. Tangential diameter 16.10–47.74–80.50 $\mu$m. Radial diameter 18.40–57.68–112.70 $\mu$m. Length of vessel members up to 92.00–139.65–230.00 $\mu$m; with small, alternate, elongated bordered pits on their wall. Simple perforate plate.

Medullary rays 1–2, rarely 3 cells wide, with heterogeneous structure. Height 69.00–210.91–448.50 $\mu$m. Width 11.50–14.49–23.00 $\mu$m. Medullary ray cells rarely contain gum (Figs 12 and 13).

Fibres are arranged in radial rows, rarely in irregular position. Diameter up to 4.68–8.26–12.48 $\mu$m. Wall thickness 0.78–1.38–1.56 $\mu$m. Full length up to 213.00–433.81–639.00 $\mu$m. Tip of the fibres ending in a point.

Diameter of the longitudinal parenchyma cells up to 9.20–12.69–18.40 $\mu$m. Height 41.40–80.31–128.80 $\mu$m.

## *Capparis stenosepala* Urb.

Diffused-porous wood. The basic mass of wood is formed by polygonal-shaped fibres with thicker wall and narrower lumen. Paratracheal aliform-confluent longitudinal parenchyma. Medullary rays 1 and 2 cells wide (Fig. 14).

Roundish or oval-shaped tracheae, rarely solitary, tangentially flattened in the groups. In the vessel groups (2–6 members) there are some small tracheid-like vessels, too. Large

**Table 1**

*Anatomical characteristics of the examined species*

| Wood elements | Features | *C. sessilis* | *C. pachaca* |
|---|---|---|---|
| Trachea members | Arrangement | Diffused, solitary or radial group (2–10 members) | Diffused, solitary or radial group (2–12 members) |
| | Shape | roundish or oval; group radially flattened | roundish or oval; group radially flattened |
| | Tangential diam. | 20.70– 47.10– 57.50 μm | 25.30– 51.84– 78.20 μm |
| | Radial diam. | 20.70– 40.94– 59.50 μm | 29.90– 60.16– 89.70 μm |
| | Length of vessel members | 119.60–155.94–211.60 μm | 110.40–160.63–220.80 μm |
| | Number per mm$^2$ | 32.00– 43.48– 70.00 | 15.00– 23.00– 34.00 |
| | Wall thickness | 2.30– 3.91– 6.90 μm | 2.30– 4.89– 9.20 μm |
| | Intervascular pitting | small, elongated, bordered | small, bordered |
| | Perforation plate | simple | simple |
| | Content | gum | — |
| Medullary rays | Width | narrow | narrow |
| | Number of cells | 1–4 | 1–2, rarely 3 |
| | Classification | homogeneous, or heter. | homogeneous or heter. |
| | Height | 34.50–209.07–437.00 μm | 46.00–226.09–540.50 μm |
| | Width | 11.50– 32.66– 57.50 μm | 11.50– 39.90– 57.50 μm |
| | Content | rarely gum | — |
| Fibres | Arrangement | radial rows | radial rows |
| | Shape | polygonal | polygonal |
| | Full diameter | 7.80– 13.41– 17.16 μm | 6.24– 10.51– 14.04 μm |
| | Wall thickness | 1.56– 1.73– 3.12 μm | 1.56– 2.49– 3.12 μm |
| | Full length | 142.00–297.50–426.00 μm | 284.00–416.10–639.00 μm |
| | Type of pits | small, with slot | very small, aspirated |
| Longitudinal parenchyma | Arrangement | contact-vasicentric | contact-vasicentric |
| | Diameter | 9.20– 14.03– 23.00 μm | 9.20– 14.21– 23.00 μm |
| | Height | 27.60– 57.59–138.00 μm | 27.60– 49.49– 96.60 μm |
| | Number of cells | 2–3 | 3–6 |
| | Content | rarely gum | — |
| | Other | — | — |

**Table 2**

*Anatomical characteristics of the examined species*

| Wood elements | Features | C. odoratissima | C. stenosepala |
|---|---|---|---|
| Trachea members | Arrangement | Diffused, rarely solitary; in radial or irregular groups (2—4 members) | Diffused, rarely solitary; in radial or rarely irregular groups (2—6 members) |
| | Shape | Roundish or oval, some-times tangentially flattened | Roundish or oval, sometimes tangentially flattened |
| | Tangential diam. | 16.10– 47.74– 80.50 μm | 27.60– 64.49–103.50 μm |
| | Radial diam. | 18.40– 57.68–112.70 μm | 20.70– 63.31–115.00 μm |
| | Length of vessel members | 92.00–139.65–230.00 μm | 119.60–212.88–303.60 μm |
| | Number per mm² | 26.00– 31.48– 40.00 | 6.00– 20.44– 28.00 |
| | Wall thickness | 2.30– 4.25– 6.90 μm | 2.30– 5.33– 11.50 μm |
| | Intervascular pitting | small, elongated, bordered | medium, elongated, bordered |
| | Perforation plate | simple | simple |
| | Content | rarely gum | rarely gum |
| Medullary rays | Width | narrow | narrow |
| | Number of cells | 1–2, rarely 3 | 1–3 |
| | Classification | heterogeneous | heterogeneous |
| | Height | 69.00–210.91–448.50 μm | 57.50–281.98–575.00 μm |
| | Width | 11.50– 14.49– 23.00 μm | 11.50– 31.85– 57.50 μm |
| | Content | rarely gum | rarely gum |
| Fibres | Arrangement | irregular | irregular |
| | Shape | polygonal | polygonal |
| | Full diameter | 4.68– 8.26– 12.48 μm | 9.36– 11.54– 15.60 μm |
| | Wall thickness | 0.78– 1.38– 1.56 μm | 1.56– 1.81– 3.12 μm |
| | Full length | 213.00–433.81–639.00 μm | 426.00–643.30–852.00 μm |
| | Type of pits | small, with slot | small, aspirated |
| Longitudinal parenchyma | Arrangement | contact vasicentric, rarely aliform-confluent | aliform-confluent |
| | Diameter | 9.20– 12.69– 18.40 μm | 11.50– 15.31– 18.40 μm |
| | Height | 41.40– 80.31–128.80 μm | 96.60–139.10–230.00 μm |
| | Number of cells | 2–4 | 1–2, rarely 3 |
| | Content | — | — |
| | Other | — | octahedral calcium oxalate crystal |

vessel size within the Capparis species. Their number up to 6–20.44–28. Tangential diameter 27.60–64.49–103.50 μm. Radial diameter 20.70–63.31–115.00 μm. Length of vessel members 119.60–212.88–303.60 mm; with alternate, medium-sized, elongated bordered pits on their wall. Simple perforate plate.

Medullary rays up to 1–2, not rarely 3 cells wide, with heterogeneous structure. Height up to 57.50–281.98–575.00 μm. Width 11.50–31.85–57.50 μm. Ray cells rarely contain gum (Figs 15 and 16).

Fibres are in irregular position. Diameter up to 9.36–11.54–15.60 μm. Wall thickness 1.56–1.81–3.12 μm. Full length 426.00–643.30–852.00 μm. Tip of fibres ending in a smooth point.

Diameter of longitudinal parenchyma cells up to 11.50–15.31–18.40 μm. Height 96.60–139.10–230.00 μm. The cells rarely contain octahedral calcium oxalate crystal.

Detailed anatomical characteristics of the wood of four *Capparis* species are described in Tables 1 and 2.

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*Acta Botanica Academiae Scientiarum Hungaricae, Vol. 28 (1–2), pp. 15–64 (1982)*

# EAST AFRICAN BRYOPHYTES, V

†M. BIZOT[1] and T. PÓCS[2]

[1] LABORATOIRE DE BOTANIQUE, FACULTÉ DE PHARMACIE, DIJON
[2] RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT

(Received: 20 April 1981)

Chorological data with taxonomic annotations accompany the new localities of 217 species collected by T. PÓCS and his colleagues in East Africa, mostly in Tanzania. 11 species are reported for first time from East Africa, other 3 are new for tropical Africa and further 14 proved to be new for the whole continent. The authors established the following new combinations and new names: *Jonesiobryum sphaerocarpum* (Biz.) Biz. et Pócs comb. nov., *Squamidium biforme* (Hpe) Broth. var. *densirameum* (Broth.) Biz. stat. nov., *Fabronia bizotii* Pócs stat. et nom. nov., *Lopidium struthiopteris* (Brid.) Fleisch. var. *campenonii* (Ren. et Card.) Biz. stat. nov., *Papillaria africana* (C. Müll.) Jaeg. var. *flagellifera* Bizot is described as new and many new synonyms are introduced. Finally a key of African *Schoenobryum* species, distribution maps of 13 species, habitat photos and phytogeographical evaluation are supplied.

## Introduction

As in our East African Bryophytes III (BIZOT and PÓCS 1980: 223) it was mentioned, this contribution is a direct continuation of East African Bryophytes (further EAB) III, with some addition and data on liverworts too. Therefore we do not intend to repeat, for sake of economy, the informations and abbreviations given in EAB III, they are valid without alteration here (EAB IV by BIZOT et al. 1978 was published earlier, than EAB III). The specimens were identified and annotated by the late prof. M. BIZOT (B) and by T. PÓCS (P), in some cases by R. GROLLE, by J. L. DE SLOOVER, or by A. TOUW. In addition to the collections mentioned in EAB III, we received 5 more specimens for identification from the Herbarium of the New York Botanical Garden (NY). The junior author expresses his gratitude for all these contributions.

## List of species collected

### HEPATICAE

1. **Lophocolea cuspidata** (Nees) Limpr. — *Erica* forest, te. *ABE: Nat. Park, 3000 m (c. H. BALSLEV 656, NY); det. P. EAB IV.
2. **Plagiochila squamulosa** Mitt. — *Erica* forest, ct. *ABE: Nat. Park, 3000 m (c. H. BALSLEV 649, NY); det. P. East African montane species, EAB IV, new to Kenya.
3. **Porella hoehnelii** Steph. — *Erica* forest, ct. *ABE: Nat. Park, 3000 m (c. H. BALSLEV 651A, NY);det. P. EAB I, IV.
4. **Odontolejeunea tortuosa** (Lehm et Lindenb.) Steph. — Montane forest, ph. ULU: Bondwa E 1600 m (6181/U); det. P.
5. **Drepanolejeunea cambouena** Steph. — Montane forest and mostly in elfin woodland, ph. *WUS: Mazumbai U.F.R. 1750–1880 m (6372/CF p.p.); ULU: Lupanga S 1900–

2000 m (6287/Q); Bondwa top 2000–2120 m (6013/B, 6052/BC, 6388/L, 6889/CE); Magari peak and E 2000–2340 m (6297/AJ, 6299/O, 6300/AR); det. GROLLE. It is not a synonyme of *D. cultrella* (Mitt.) Steph., as VANDEN BERGHEN (1977: 209) treates it, but is a distinct Lemurian species resembling much more the Asian *Drepanolejeunea dactylophora* (Nees) Spr. than *D. cultrella* and belongs to the Section *Digitatae* Herz. Annotation by P.

6. **Drepanolejeunea cultrella** (Mitt.) Steph. — Submontane and montane forests, ph. *KEN: Castle F. St. 1960–2000 m (6604/E p.p., F p.p. and 6604/H); TAI: Mbololo Hill 1450–1600 m (c. Faden 71/968/D, J, M, Q, T); *Kasigau Hills E 1250–1640 m (c. Faden s.n. 6. Feb. 1971); *WUS: Mazumbai U.F.R. 1600–1880 m (6371/AJ, 6372/CFB); *EUS: Amani 860–900 m (6105/AT, 6088/C, D, E, G, etc.); *NGU: W of Kwamanga village, 1100–1450 m (6397/AD); *UKA: Mnyera ridge NNE 1900–2130 m (6739/AA, 6740/BB); *KAN: S 1370 m (6140/AJ, AP); ULU: Kinole sawmill 1050–1200 m (6874/AA, AB); Tumbako SE 1390–1480, S 1500 m (6876/AD, AE, AG, 6877/AA, AP, AU, AY); Mwere v. 1500–1630 m (6176/E, F, G, 6221/C); Lupanga NW 1500–1850, S 1700–1900 m (6547/G p.p., 6285/AD, AJ, 6124/A), top 2140 m (6072/AA, AD); Lupanga-Kinazi ridge 1800–1900 m (6836/BC, BJ); Kinazi NW 1400–1650 m (6289/AC); Palata NW 1700–1890 m (6851/AB, AE, 6852/AA); Bondwa top and slopes 1600–2120 m 14 records !; Magari peak 1500–2345 m (6296/AA, 6297/AC, 6299/N, 6300/BB, BC); Kibungo W 1500–1700 m (6475/B, 6476/AA); Bunduki, Kikododo 1750–1900 m (6464/BB); *KIL: Mweka route 2150 m (6344/BE, BF, BG); *RUN: Mt. Rungwe SW 1800–2050 m (6762/C, 6763/AB); det Grolle. Widespread in the mountains from Sao Tomé to East Africa, EAB I.
7. **Drepanolejeunea pocsii** Grolle — Epiphyllous in submontane and in montane forests, elfin woodlands. *KAN: S 1370 m (6140/AI p.p.); ULU: Lupanga S 1700–1900 m, NW 1400–2000 m (6285/AE, AK, AL, etc., 6124/B); Lupanga — Kinazi 1800–1900 m (6836/BH); Palata NW 1700–1890 m (6851/AC, AD, AG, 6852/AC, AD, AE); Mwere v. 1400–1600 m (6156/E, G); Magari peak NNE 1500–1800 m, E 2000–2100 m (6296/AB, AC, AE, 6297/AA, AC, etc.); RUN: SW 2050 m (6763/AA, AC); det. Grolle. Along the localities reported by GROLLE (1976: 210) and here, the species is known also from Zimbabwe, Mt. Peni (VANDEN BERGHEN 1978: 444–445).
8. **Drepanolejeunea friesii** Vand. Bergh. — Epiphyllous and ramicolous in submontane and montane forests, elfin woodland and in subalpine Erica heath. KIL: Umbwe route 2800–2900 m (6929/NA); Marangu route 2200–2650 m (6240/O, Y, 6365/K, U); above Nkweseko village, 1800–1850 m (6359/E); *UKA: Mnyera ridge NNE 1900 m (6870/BF p.p.); *KAN: S 1370 m (6140/AH); *ULU: Lupanga S 1700–2000 m (6285/BY, 6287/Q); Tumbako S 1500 m (6877/AO3); Bondwa top 2100 m (6233/N, 6889/M); Bondwa NE 1740 m (6844/GD); Midhani 880 m (6881/AO); Mgeta v. E of Lukwangule Pl. 2250 m (6830/AH); W of Kibungo Mission 1500–1700 m (6475/AD); Magari peak 2345 m (6300/AS, BA); det. GROLLE and P. East African — Lemurian montane species.
9. **Drepanolejeunea trematodes** (Nees) Bischl. — Epiphyllous in montane forests, elfin woodland and in bamboo thickets. KEN: Castle F. St. 1960–2000 m (6604/G); ULU: Bondwa E 1700–1900 m, N 1700–2050 m, top 2120 m (6117/A, B, C, 6119/M, 6259/E, 6013/A, 6052/BE, 6536/A, 6598/C, etc.); Mwere v. 1500–1630 m (6176/C, D); Palata NW 1850 m (6852/AB, AF); det. GROLLE. East African — Lemurian montane element, very doubtful in Mexico (cf. GROLLE 1976: 207).
10. **Diplasiolejeunea kraussiana** (Lindenb.) Steph. — Epiphyllous in montane forests. *KIL: NE of Mweka, Mnangue R. valley 1900 m (6343/BO); *ULU: Mgeta v. E of Lukwangule plateau, 2250 m (6830/BC); det. P. Known from Burundi through Zimbabwe to Cape.
11. **Diplasiolejeunea zakiae** P. Tix. — The species collected in East Africa by FADEN, PÓCS and others, identified by GROLLE previously as *D. utriculata* Steph. and a few Kenyan records published under this name by BIZOT and PÓCS in EAB I. (1974: 411, No. 108)

proved to be a new species, as GROLLE recognized it, and distinguished under the name of *Diplasiolejeunea tubulata* Grolle sp. n. Herbarium specimens of the new species were circulated under this unpublished name, when TIXIER (1977: 123) published his *D. zakiae* from Madagascar. He refers to *D. tubulata* Grolle 1966 erroneously, because *D. tubulata* was never published, not even in the paper cited by TIXIER (1977: 125). TIXIER compares *D. zakiae* with *D. tubulata* and treates them, as separate species. In fact, *Diplasiolejeunea tubulata* Grolle nom. herb. is the same as *Diplasiolejeunea zakiae* Tixier, which is this way the valid name for the species concerned. New records of *Diplasiolejeunea zakiae* P. Tix.: *K: Taita hills, Mbololo hill 1450–1800 m (c. R. B. FADEN et al. 71/968/X — Type of *Diplasiolejeunea tubulata* Grolle, 71/1020/G); Taita hills, Mraru ridge, 1440–1680 m (c. R. B. FADEN et al. 70/769); *ULU: Tumbako 1390–1530 m (6876/AC, 6877/AJ); Lupanga SW 1700–1900 m (6285/AQ); Mwere v. 1500–1630 m (6176/Q); Bondwa E 1600 m (6181/Q); Madagascar: R. N. du Marojejy, 1450 m (c. GUILLAUMET 4133/5). A strictly epiphyllous montane rain forest species distributed in the crystalline massivs of East Africa and Madagascar. Annotation and identification by GROLLE and P.

12. **Cololejeunea cuneata** (Lehm. et Lindenb.) Steph. — Epiphyllous in montane rain forest. *WUS: U.F.R., Kambo, 1620 m (6374/BM) associed with *C. leloutrei* and *C. cardiocarpa*. Det. P. New for the continent, previously known from Madagascar and from Mauritius.
13. **Cololejeunea cardiocarpa** (Nees et Mont.) Schust. WUS: Mazumbai U.F.R.: Kambo, 1620 m (6374/BO) epiphyllous in montane forest; det. P. EAB I, III, pantropical.
14. **Cololejeunea filicaulis** Steph. — Epiphyllous in submontane and in montane rain forests. *K: Taita hills, Mbololo hill, Mraru ridge 1440–1680 m (c. R. B. FADEN et al. 70/765) Kasigau hill 1250–1600 m (c. R. B. FADEN s.n.); *KEN: Castle F. St. 1960–2000 m (6604/L); *ULU: Mwere v. 1400–1600 m (6156/B, published in EAB I No. 95 as *C. grossidens*); Kinole sawmill 1100 m (6874/AL, published in EAB III No. 112 as *C. malanjae*); det. P. Palaeotropical species known from Cameroon to Tanzania, Madagascar and to Réunion, from tropical SE Asia and Malaysia to Oceania, detailed distribution given by TIXIER (1975: 467).
15. **Cololejeunae tanzaniae** Pócs — Epiphyllous in submontane rain forest. ULU: Mt. Tumbako SE 1400 m (6876/AL); det. P. Recently described species (PÓCS 1980: 312) with East African — Madagascan distribution.
16. **Mannia capensis** (Steph.) S. Arnell — On relatively dry, open granitic rocks. *ULU: Hululu Falls S of Bunduki, 1480 m (6902/A); det. GROLLE. South African species known from Cape, Namibia, Zimbabwe, Zambia: Victoria Falls. New for East Africa.

## MUSCI

### Funariaceae

— **Jonesiobryum sphaerocarpum** (Bizot) Bizot et Pócs **comb. nov.** M. R. Crosby kindly turned our attention to the fact, that even we introduced a new name instead of the illegitimately published *Jonesia* Bizot et Pócs non *Jonesia* Roxb.: *Jonesiobryum* Bizot et Pócs (1974: 444), we did not make a new combination for the species, therefore the species name remained invalid. Therefore we propose the above new combination based on *Jonesia sphaerocarpa* Bizot nom. inval. in BIZOT, PIERROT and PÓCS, Rev. Bryol. et Lichénol. 40: 25 (1974).
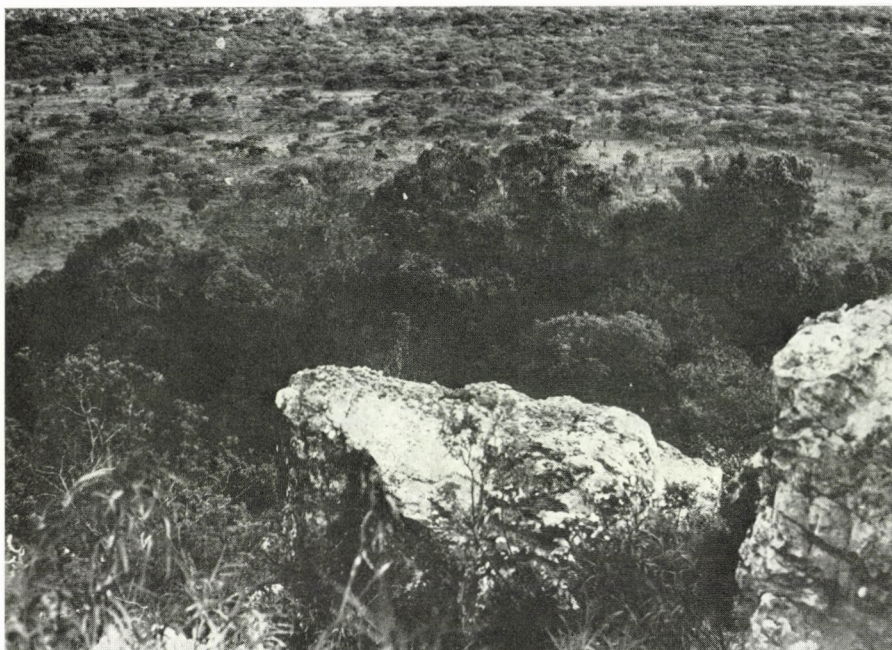
*Fig. 1.* Evergreen montane forest patch surrounded by dry deciduous Brachystegia woodland (miombo) on the E slope of Mt. Mukowonshi, NNE of Mpika in Zambia, at 1800–1900 m alt. Locality of *Calyptothecium planifrons, Mittenothamnium microthamnioides, Rhacopilopsis trinitensis, Acanthocladiella flexilis, Pilotrichella ampullacea* and others
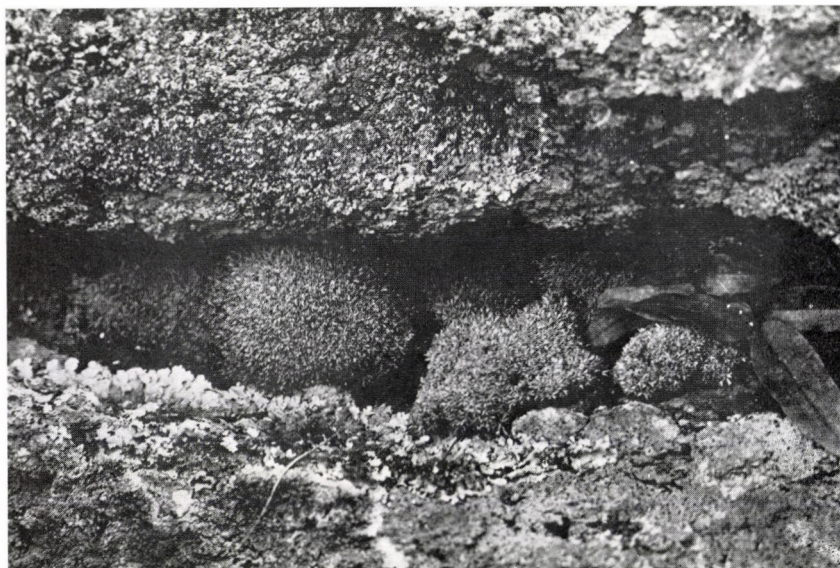
*Fig. 2. Octoblepharum albidum* in dry granite rock crevices, accompanied by *Fabronia longipila* and by *Gyroweisia pocsii,* on the SW foothills of Nguru ya Ndege, N of Morogoro, Tanzania, at 600 m alt

*Fig. 3.* Lowland rain forests near Sanje Falls in Mwanihana Forest Reserve, Gologolo Mts. (Usagara), Tanzania, at 300 m alt. Locality of *Cololejeunea adhaesiva*, *Lejeunea tuberculiflora*, *Lopholejeunea kilimanjarica*, *Cyathodium africanum*, etc.

### Rhizogoniaceae

17. **Rhizogonium spiniforme** (Hedw.) Bruch. — Corticolous, ramicolous and lignicolous in submontane and montane forests, elfin woodlands. *UKA: Ikwamba N 1875–1920 m (6866/J); ULU: Lupanga NW 1300 m (6064/J); Lupanga — Kinazi ridge 1800–1900 m (6836/M); Palata NW 1700–1850 m (6851/L); det. P. Pantropical.

### Bartramiaceae

18. **Leiomela africana** Thér. et Nav. — Almost always on tree fern stems, rarely on bark, in very wet montane rain forests (mossy forests). According to De Sloover (1975: 317) all tropical African *Leiomela* belong to the above taxon. We published this plant from several localities in EAB I, No. 269 under the name of *Leiomela bartramioides* (Hook.) Par. cf. var. *borbonicum* Besch. The data below are new: *KEN: Castle F. St. 2000 m (6603/S); KIL: Kimefu v. near Nkweseko 1850 m (6360/N); *UKA: Mt. Kifigo SE 1825 m (6592/K); Mt. Ikwamba N 1900 m (6866/D); ULU: Lupanga S 1750–1950 m (6468/A);

*Fig. 4. Pandanus* cf. *engleri* stand in the lowland rain forests of Kimboza Forest Reserve, Uluguru Mts. at 300 m alt. Locality of *Cyathodium africanum, Frullania nodulosa, Cololejeunea jonesii, Calymperes usambaricum, Erpodium biseriatum, Fissidens atroviridis, F. gomae, Anacamptodon africanus* and *Neckeropsis lepineana*

WNW 1900–2050 m (6550/T) Mwere v. 1450–1560 m (6158/N, 6891/E): Kilangala SE of Bunduki 1750–1990 m (6464;BL); Mgeta v. 1600–1640 m (6912/J); det. De Sloover. Characteristic species of bryophyte communities living on tree fern stems in the East African mountains from Ruwenzori Mts. to the Ulugurus and in Réunion island.

19. **Bartramia hampeana** C. Müll. — On humus covered rocks at the forest edge. *ULU: Mgeta falls at the E escarpment of Lukwangule plateau, 2350 m (6822/AB); det. B. South African.
20. **Bartramia jungneri** Par. — On a cliff surrounded by ericaceous woodland with giant Senecios. *KIL: Umbwe route near the IInd Bivouac, 3330 m (6791/NA); det. B. Previously known only from the Cameroon, Kenya and Uluguru Mts.
21. **Bartramia** cf. **microcarpa** P. Varde — On wet volcanic rocks. *KIL: Mweka route, Charongo v., 2985 m (6719/K, L); det. B. Afroalpine species known from Zaire, from the Ruwenzori Mts. and from Mt. Elgon.
22. **Bartramia gigantea** Bory — On dry volcanic rocks surrounded by *Philippia* heath, or on granitic rocks. *KIL: Near Mweka Base Hut, 3000 m (6720/R); *ULU: Mgeta falls at

the E edge of Lukwangule plateau, 2350 m (6822/AX); det. B. Previously known only from Réunion.

23. **Bartramidula globosa** (C. Müll.) Broth. — *KIL: Umbwe route, on volcanic rocks of the IInd Bivouac, 3330 m (6791/GA); det. B. East African montane species from Mt. Elgon (3600 m) to Cape, new for Tanzania.
24. **Philonotis africana** (C. Müll.) Rehm. ex Par. — On the ground of "dambo" moorland. *Z: Along the Great East Road between Unda-Unda and Rufunza, 125 km from Lusaka, 1100 m (6619/E); doubtful species previously known only from Natal. Det. and annotation by B.
25. **Philonotis fontana** (Hedw.) Brid. — On irrigated rocks and boggy ground of giant Senecio moorland. KIL: near Barranco Hut, 3850–3950 m (6794/G, 6796/B); det. B. Northern temperate species, altimontane in tropical Africa, known between 3450 and 4350 m.
26. **Philonotis hastata** (Dub.) Wijk et Marg. — Ubiquist in wet tropics, occurring not only on rocks, but also on (often cultivated) soil, on flowerpots, on concrete dikes and near waterfalls even on tree branches. T: Mwanza townsip 1136 m (6199/B); KIL: Marangu, Kinukamari Falls 1500 m (6237/L); Lyasomboro 1850 m (6208/D); EUS: Amani 850 m (6095/D); *NGU: Mnembule 1400 m (6437/F); *UKA: waterfall below Mandege F. St. 1200 m (6744/B); ULU: Morogoro, all valleys near the town, 600–1300 m (6004/C, 6401/AK, 6561/C, 6723/B); Hululu Falls S of Bunduki 1460–1500 m (6900/J, 6902/B); Kinole sawmill 1100 m (6874/N); Milawalila F.R. 400 m (6416/K); Kisimbi Falls 650 m (6276/J); Kimboza F.R. 300 m (6271/C); *USG: Mwanihana F.R. below Sanje Falls, 300 m (6144/AB); *RUN: Isongole village, 1960 m (6757/A); Z: Victoria Falls, Knife Edge, 870 m (6613/H); det. B. Very widespread pantropical species.
27. **Philonotis platyneura** P. Varde — On irrigated rocks along a streamlet in Senecio moorland. *KIL: Behind Barranco Hut, 3850 m (6794/E); det. B. Afroalpine species previously known only from Ruwenzori Mts.
28. **Philonotis tomentella** Mol. in Lor. — On irrigated rocks. KIL: Near Shira Hut, 3660 m (6927/AG); det. B. Temperate species, disjunct in tropical mountains, EAB I, IV.
29. **Breutelia diffracta** Mitt. — On siliciferous rocks in montane forest and in the ericaceous belt. *NGU: Mt. Mafulumula E 1850 m (6439/L); RUN: Mt. Kyejo E of Tukuyu, N 1700 m (6770/B); Mt. Rungwe, caldera rim + mean peak E 2500–2600 m (6506/G, 6504/Y); det. De Sloover. Afromontane species, EAB I.
30. **Breutelia perrieri** Thér. — Giant Erica heath, on the mossy ground. *KIL: Umbwe route, near the Ist Bivouac, 2850 m (6788/BL); det. De Sloover. Previously known from Mt Meru, from Madagascar and from Réunion.
31. **Breutelia borbonica** J. L. De Sloover — On rocks and soil of ericaceous subalpine heath. *KIL: Umbwe route 3330 m, near the IInd Bivouac (6791/C); *MER: W 3750 m (coll. J. Szunyoghy 21/a); det. De Sloover. [M. Bizot previously identified, as *Breutelia kilimandscharica* (C. Müll.) Par.] *Breutelia borbonica* is new for continental Africa, previously known only from Réunion.
32. **Breutelia humbertii** P. Varde et Thér. — On rocks in subalpine ericaceous heath. *MER: W 3900 m (coll. J. Szunyoghy 20/c); det. J. L. De Sloover. Afroalpine species, previously known only from the Birunga volcanoes.
33. **Breutelia muhavurensis** P. Varde et Thér. — On subalpine rocks. KEN: Teleki v. W 3900 m (coll. D. Balázs 105/c); Afroalpine species, published under *B. subgnaphalea* (C. Müll.) Par. by Bizot (1973: 23), revid. by De Sloover.
34. **Breutelia stricticaulis** Dix. — On the ground of Erica giant heath. KEN: Naro Moru track, 2500 m (coll. D. Balázs 102 p.p.); det. De Sloover. Afroalpine species published by M. Bizot from the above locality under the name of *B. Stuhlmanii* Broth. (Bizot 1973: 23.)

35. **Breutelia gnaphalea** (P. Beauv.) Mitt.; Journ. Linn. Soc. Bot. 7: 153 (1864); *Hypnum gnaphaleum* P. Beauv., Prodr.: 64 1805; Syn. nov.: *Breutelia ryvardenii* Bizot, Rev. Bryol. et Lichén. 42: 850 (1976). — Althought already BARTRAM (1953: 194) published this species with question mark from the Mulanje Mts. and BIZOT, DURY and PÓCS EAB II. (1976: 5) confirmed its occurrence based on the recent collection made by RYVARDEN (det. J. L. DE SLOOVER), BIZOT (1976: 42) described it, as a new species from the same collection of RYVARDEN. In fact, as J. L. DE SLOOVER confirmed (in litt.), *B. ryvardenii* Bizot agrees in all aspects with *Breutelia gnaphalea* (P. Beauv.) Mitt. and the previous identifications were right. Annotation by P.

## Erpodiaceae

36. **Erpodium biseriatum** (Aust.) Aust. — On half shady limestone or crystalline rocks of lowland rain forest or riverine forest. ULU: Kimboza F.R. 300 m (6728/E); Kimboza — Mkuyuni 350 m (6729/A, 6800/O, S, 6801/J); NGU: W of Mhonda Mission 550–800 m (6399/G); det. P. Pantropical species, in EAB I, No. 282 published under synonyme *Solmsiella biseriata* (Aust.) Steere.

## Orthotrichaceae

37. **Zygodon intermedius** B. S. G. — Corticolous in montane forests. *KIL: Marangu route 1900–2200 m (6364/J); T: *Kipengere Range: Kitulo Plateau 2650 m (6750/AW); RUN: Mt. Rungwe SW 2450 m (6766/Z); det. B. Pantropical species widespread in African mountains, EAB I.
38. **Zygodon microtheca** Dix. ex Malta — Corticolous in montane forests and in *Juniperus excelsa* plantation. *WUS: Near Misalai between Soni and Bumbuli, 1500 m (6369/C); *ULU: Bondwa NE 1740 m (6578/BL); det. P. Previously known from Ruwenzori, Kivu, Southern Highlands of Tanzania. Seems to be very closely related to the Ceylonese *Zygodon humilis* Thw. et Mitt. and also to the other species of the "Artengruppe von *Z. pungens*" of Malta (1926: 148). Its difference from the following species might be not specific. Annotation by P.
39. **Zygodon pungens** C. Müll. — Corticolous in montane forest. *ULU: Mgeta river valley above Hululu Falls, 1640 m (6912/S); det. B. On the base of the strong, yellowish brown costa belongs typically to this species, but its small stature shows relation with *Z. parvulus* Geh. et Hampe, which might be only a habit form of *Z. pungens*. The *Zygodon pungens* group badly needs a revision. *Z. pungens* is a Latin American species distributed from Guatemala to Brasil, new to Africa. Annotation by P.
40. **Zygodon reinwardtii** (Hornsch.) Braun — On giant Senecio stem. *ABE: Gikururu valley, 1.5 km W of Kiandogoro Gate, 2950 m (coll. MABBERLEY 327/A); det. B. Seem to be an oceanic cosmopolite, altimontane in Africa, cf. EAB IV.
41. **Zygodon trichomitrius** Hook. et Wils. var. **mildbraedii** (Broth.) Malta — On basaltic rocks in *Philippia* heath. *KIL: Around Mweka Base Hut, 3000 m (6720/RB); det. B. East African montane species, from Elgon to Cape, EAB I.
42. **Amphidium tortuosum** (Hornsch.) Robins Syn.: A. *cyathicarpum* (Mont.) Broth. — In lava caves, especially on their ceiling. KIL: Umbwe route, Ist Bivouac, 2900 m (6788/AF); Shira route, near Shira Hut 3660–3700 m (6926/C, 6927/AB); det. B. Widespread in the Southern Hemisphere, altimontane in tropical Africa, EAB IV.
43. **Leptodontiopsis fragilifolia** Broth. — On giant *Senecio* stems and on rocks in *Senecio* moorland and in *Helichrysum* cushion community. KIL: Umbwe route, near the IInd

Bivouac, 3550 m (6792/A); near Barranco Hut, 3850–3950 m (6795/E); S of Shira Hut 3660 m (6927/P); det. B. Afroalpine species, EAB IV.

44. **Rhachithecium perpusillum** (Thwait. et Mitt.) Broth. — Corticolous on scattered *Albizzia* trees in a coffee plantation. KIL: Mawingo Estate near Mweka village, 1350 m (6350/E). Disjunct pantropical species, EAB I.

45. **Macromitrium fasciculare** Mitt. — Corticolous in elfin woodland. *ULU: Lukwangule Plateau, centre and S edge, 2400–2500 m (6814/B, 6825/N); det. B. Palaeotropic species known from the Philippines to Madagascar, new for continental Africa.

46. **Macromitrium levatum** Mitt. — Corticolous in submontane and in montane forests, occasionally on wet rocks and on porous lava too. *KEN: Kamweti track 2400–2700 m (6601/AD); MER: E 2100 m, near Yekukumia (6519/D); NGU: Mafulumula, N peak above Mnembule village, 1920 m (6440/L); Dunema ridge 1400–1500 m (6398/R); ULU: Lupanga SW 1500–1900 m (6284/AH, 6285/CK); NW 1700–2000 m (6126/D, 6129/F); Bondwa NE 1740 m (6578/AB); Tumbako SE 1050–1520 m (6264/K, 6876/Q); Mt. Mindu S 1200 m (6492/L, 6843/A, Y); Tegetero Mission 975–1300 m (6424/W, 6427/C); Lukwangule Plateau edge near Mgeta Falls, 2350 m (6822/Y); *RUN: Mt. Rungwe SW 2450 m, E 2500–2600 m (6766/G, 6504/T); Mt. Kyejo N 1700 m (6770/F); *Z: "Cloud Forest" in

*Fig. 5. Fissidens crassipes — Philonotis marangensis — Hydrogonium afrofontanum* community on irrigated aerial roots near a waterfall in the Great Ruaha River gorge ("Stiegler Gorge") near Kidatu, Tanzania, 480 m alt.

*Fig. 6.* Mist effected bark of an Acacia tree in the dry woodlands of Kiboriani peak above Mwapwa, Tanzania, 2000 m alt. *Brachymenium leptophyllum* with *Leptodontium viticulosoides* and with *Macrocoma tenue*

Mukowonshi Mt. 45 km NNE of Mpika, E 1800–1840 m (6629/Z); det. B. Widespread afromontane species from Guinea to Madagascar, EAB I, IV.

47. **Macromitrium rufescens** Besch — In montane forests, elfin woodland, ct, ra, ru. *WUS: Mazumbai UFR. 1750–1880 m (6372/AY, AZ); *UKA: Mnyera ridge, 2100 m (6740/AM); *ULU: Lupanga — Kinazi ridge, 1800–1900 m (6836/AP, AS); Bondwa NE 2120 m (6733/B); *RUN: Mt. Rungwe SE, 2500–2600 m (6767/T); det. B. East African — Lemurian species, EAB IV.
48. **Macromitrium subpungens** C. Müll. — Ramicolous, in submontane rain forests. EUS: Seems to be very common near the Amani Forest Houses, where EAB IV also reported, at 900 m (6100/H, 6086/BN, 6087/K, 6293/D); Hunga v. 880 m (6881/AR); *NGU: Mhonda Mission W 800–1000 m (6400/PB); *ULU: Mt. Mindu S 1200–1240 m (6843/AC, AF); Midhani 880 m (6880/AC, 6881/AR); Tumbako SE 1050 m (6264/J); det. B. East African — Lemurian species, EAB IV.
49. **Macromitrium tristratosum** Mitt. — Corticolous in lowland and in submontane forests. EUS: Amani 900 m (6086/BO, 6087/W); ULU: Palata N 1600–1690 m (6850/P); Kimboza F.R. 300 m (6301/B); det. B. E and S Africa, Madagascar, EAB I, IV.

50. **Macromitrium** cf. **urceolatulum** C. Müll. ex Geh. — *EUS: near Sigi village, on cultivated palm trunks, 500 m (6375/E); det. B. New for continental Africa, previously known only from Madagascar.
51. **Groutiella laxotorquata** (Besch.) Wijk et Marg. — Corticolous and on rocks in submontane forests. *NGU: Duale valley near Mhonda Mission, 550 m (6434/C); ULU: Mt. Mindu S 1200–1240 m (6843/R); Tegetero Mission 975 m (6424/UB); *RUN: Below Lugumbo village, 1225 m (6768/FB); det. B. According to D. VITT (personal communication) it is not synonymous with *G. tomentosa* and therefore restricted to the low, wetter part of tropical Africa. EAB I, IV.
52. **Schlotheimia angulosa** (P. Beauv.) Dix. Ramicolous in elfin woodland. *ULU: Bondwa top S 2120 m (6889/BS); det. B. New for continental Africa, previously known only from Mauritius.
53. **Schlotheimia excorrugata** C. Müll. ex Card. — Corticolous, in montane forests and in elfin woodland. *ULU: Lupanga NW 1500 m (6067/L); Morningside 1420 m (6414/M); Palata 1500–1700 m (6849/E, 6850/N); *UKA: Mnyera peak 2150 m (6740/AN); det. B. Previously known from Madagascar, new for continental Africa.

*Fig. 7.* The submontane rain forest of Amani, East Usambaras. One of the most important localities of lowland forest elements in Tanzania, at 980 m

*Fig. 8.* Montane forests at the crater rim around Lake Ngozi in the Poroto Mts. in southern Tanzania, at 2200 m alt. Locality of *Fissidens ovatus*, *F. crateris*, *F. helictocaulos*, *F. purpureocaulis*, *Prionodon ciliatus*, *Mittenothamnium brevicuspis*, *Leucoloma scabricuspes*, *Hylocomiopsis cylindricarpa*, *Porella capensis* and of many other species

54. **Schlotheimia ferruginea** (Hook. et Grev.) Brid. — On shady rocks in montane mossy forest. *WUS: Mazumbai U.F.R. 1750–1880 m (6372/AK); det. B. SE African, known from Natal to Zambia.
55. **Schlotheimia laetevirens** Broth. — Corticolous in Juniperus plantations and in montane forest. WUS: Misalai 1500 m (6369/H); *RUN: Mt. Rungwe SW 1800 m (6777/AA); det. B. Previously known from Malawi and from Tanzania: Mufindi and from the Usambara Mts.
56. **Schlotheimia malacophylla** Besch. — Corticolous in elfin woodland. ULU: Lukwangule Plateau E edge, 2350–2450 m (6827/AM); det. B. Known from Réunion and the Ulugurus.
57. **Schlotheimia percuspidata** C. Müll. — On bark in submontane and in montane forests. ULU: Tumbako SE 1050 m (6167/X, 6264/G); Bondwa N 1450 m, NE 1740 m (6528/F, 6578/AE, BJ, 6854/Q); *RUN: Mt. Rungwe SW 2100–2300 m (6764/K); det. B. SE African species, known from Cape, Natal, Transvaal, Malawi, Zimbabwe and from the Ulugurus.

58. **Schlotheimia rigescens** Broth. — On bark, branches and on rocks from lowland up to montane forests. *WUS: Mazumbai U.F.R. 1750–1880 m (6372/BA); ULU: Lupanga SW 1700–1900 m (6285/CB, CC, CD); Mt. Mindu E 975 m (6841/M); Kimboza F.R. 300 m (6809/B); Nguru ya Ndege Hill N 900, SW 1100 m (6708/O, V, 6448/Z); Tumbako 1480–1530 m (6877/F); det. B. East African montane species.
59. **Schlotheimia robusta** Thér. — Corticolous, from submontane rain forest up to subalpine elfin woodland. *NGU: Above Mnembule village, 1400 m (6437/AO); *ULU: Bondwa top 2100 m (6309/Z); Lupanga — Kinazi ridge 1800–1900 m (6836/AF); det. B. Known only from Madagascar, new to continental Africa.
60. **Schlotheimia schweinfurthii** C. Müll. — In submontane forests and woodland, corticolous. *Kitulanghalo F.R. NE of Morogoro, 700 m (6857/A); ULU: Nguru ya Ndege N 1000 m; Mt Mindu 1200 m (6492/K); det. B. Central and East African species.

**Racopilaceae**

61. **Racopilum africanum** Mitt. — On bark in mossy montane forest. *RUN: Mt. Rungwe SW 2500–2600 m (6767/Z); det. B. Widespread afromontane species, EAB I, IV.

**Hedwigiaceae**

62. **Hedwigidium integrifolium** (P. Beauv.) Dix. Syn.: *H. imberbe* (Sm.) B. S. G. — On wet rocks. *KIL: Umbwe route 3600 m (6792/F); *ULU: By the Mgeta Falls at the E edge of Lukwangule Plateau, 2350 m, intermixed with *Schistidium alpicola* (6822/AH p.p., AG); det. B. Disjunct in the Southern Hemisphere + Atlantic Europe. Altimontane in tropical Africa. EAB IV.
63. **Braunia camptoclada** P. Varde et Thér. — On bark and on rocks in relatively dry habitat. *KEN: Kamweti track 2400–2700 m (6601/X); *KIL: Mweka Wildlife College garden, 1350 m (6350/AB); Mweka route 3260 m (6720/M); *Mt. Ipiri S of Babati, 1800 m (6214/C, D); det. B. Central and East African montane, EAB I, IV.

**Cryphaeaceae**

64. **Schoenobryum latifolium** (Broth. et P. Varde) Manuel Syn.: *Acrocryphaea latifolia* Broth et P. Varde — Corticolous in montane forests. *POR: Isongole, near the lower Fishing Camp, 2000 m (6326/EB); *RUN: Mt. Rungwe N 2300 m (6334/L — published in EAB I, No. 305 under *Acrocryphaea robusta*); det. and revid. B. Central and East Africa.
65. **Schoenobryum robustum** (Broth. in Mildbr.) Manuel Syn.: *Acrocryphaea robusta* Broth. — On bark and on branches in montane forests and coffee plantations. KIL: Mweka route 1900–2500 m (6717/G); Upper Kikafu 1600–1800 m (6346/L); Marangu-Lyasomboro 1500–1800 m (6363/G, 6209/C); EUS: Amani 900 m (6102/C); det. B. East African montane species, EAB I, IV.

M. Bizot compiled an identification key for the African species of the genus *Schoenobryum*, using the nomenclature given by M. Manuel (1977: 523), as follows:

1 a Feuilles revolutées jusqu'au sommet très courtement acuminées ..... 2
  b Feuilles revolutées 3/4 environ à acumen net parfois subpiliforme ... 3
2 a Feuilles peu imbriquées à sec ovales brièvement acuminées. Nervure longue 3/4 fortement revolutées, cellules justacostales $45 \times 9$ µm
*Schoenobryum latifolium* (Broth et P. Varde in P. Varde) Manuel

b Feuilles plus appliquées à sec, cellules justacostales basilaires $30 \times 5$ $\mu$m
*Schoenobryum welwitschii* (Dub.) Manuel

3 a Feuilles planes ........................................................ 4
b Feuilles revolutées ........................................................ 5

4 a Acumen court, feuilles perichaetiales tronquées
*Schoenobryum subrobustum* (Broth. et P. Varde in P. Varde) Manuel
b Acumen fin et long, feuilles perichaetiales acuminées
*Schoenobryum plicatulum* (Dix. et Thér.) Manuel

5 a Cellules des feuilles papilleuses, acumen des feuilles perichaetiales scabre
*Schoenobryum tisserantii* (Thér. et P. Varde in P. Varde) Manuel
b Cellules non papilleuses ........................................................ 6

6 a Feuilles rameales courtement acuminées
*Schoenobryum robustum* (Broth. in Mildbr.) Manuel
b Feuilles rameales à long acumen
*Schoenobryum madagassum* (C. Müll. in Bechenan) Manuel
et *Schoenobryum subintegrum* (Ren. et Card. in Ren.) Manuel

66. **Cryphaea protensa** Bruch et Schimp. ex C. Müll. — On bark and twigs in montane forests. KIL: Marangu route near Mandara Hut, 2700–2800 m (6243/D, 6245/AD); Mweka route 2500–2900 m (6717/G, 6718/BV, CZ); det. B. East African montane species.
67. **Cryphaea robusta** Broth. et Thér. — Corticolous and ramicolous in montane evergreen and semideciduous forests. *KIL: Wasendo glade NW of Shira Plateau, 2600 m (6355/K); *NGO: Ngorongoro crater rim 2300 m (coll. BALÁZS 109f p.p., Pócs 6196/D); K: NE of Nairobi 1600 m (6607/EB); *UKA: Mt. Kifigo SE 1600–1760 m (6596/B); Mt. Ikwamba NW 1700–1875 m (6865/F); det. B. East African montane, EAB IV + K: Lamuru.
68. **Forsstroemia producta** (Hornsch.) Par. — Corticolous in dry forests, mostly in volcanic mountains. *K: NE of Nairobi, 1600 m (6607/C, EA); NGO: Ngorongoro crater rim 2300 m (6196/E); MER: Ngurdoto crater rim 1800 m (6213/M); *KIL: Wasendo glade NW of Shira Plateau, 2600 m (6355/V); det. B. East African montane species, EAB IV.

### Leucodontaceae

69. **Leucodon dracaenae** Solms ex Vent. — Epiphyte in relatively dry evergreen forests and on lava rocks above the forest line. MER: Njeku 2600 m (6520/A); KIL: Mandara route, above Mandara Hut, 2800 m; near Barranco Hut, 3950 m(!) on rocks (6245/AG, 6793/O); det. B. Widespread East African montane species from Erythrea to S Tanzania.
70. **Leucodon laxifolius** C. Müll. et Fleisch. — On bark and on the ground cf montane forest. KIL: Mweka route 2530–2890 m (6718/AZ, DB); det. B. East African montane species, EAB I.
71. **Antitrichia curtipendula** (Hedw.) Brid. — Epiphyte in montane forests, on rocks and on the boggy ground of Senecio cottonii moorland in the subalpine ericaceous belt. KIL: Mandara Hut, 2700 m (6243/Q); near Barranco Hut 3950 m (6793/P, 6796/F); det. B. EAB I, altimontane in East Africa.
72. **Pterogonium gracile** (Hedw.) Sm. — In East Africa the typical epiphyte of relatively dry montane evergreen forests (*Podocarpus gracilior, Juniperus excelsa, Olea chrysophylla*), occurs also on sole trees, at forest limit, exceptionally in giant bamboo thicket (*Arundinaria alpina*), also on rocks above the forest line. Often associated with Leptodon

smithii, forms a "mediterranean" community (cf. Pócs 1976: 103–104). KEN: Castle F. St. 2020 m (6602/LB); *NGO: Oldonyo Oldeani N 2700–3000 m (6920/O); *NGU: Mafulumula coll above Mnembule village, 1650–1800 m (6438/AB); det. B. EAB I, IV. Montane in East Africa.

### Prionodontaceae

73. **Prionodon ciliatus** Besch. — Corticolous in elfin woodland. *ULU: Lukwangule Plateau E 2350 m (6828/X); det. B. East African — Lemurian element, EAB I + Ethiopia and Mt. Meru.

### Rutenbergiaceae

74. **Neorutenbergia usagarae** (Dix.) Bizot et Pócs — A typical epiphyte of branches and thin stems in the montane mossy forests and elfin woodlands of the crystalline massifs of East Africa. In Bizot et al. (1974: 27–29) only 1–2 data are given from each mountains, where it occurs. The further data prove, how widespread is it in the concerned mountains.

*Fig. 9.* The interior of the very humid montane rain forest in the Mwere valley of Uluguru Mts. at 1600 m alt. On the *Cyathea* stems characteristic community of *Rhizofabronia perssonii* var. *sphaerocarpa*, *Leiomela africana*, *Fissidens jonesii* and *Lejeunea cyathearum*. Very rich epiphyllous vegetation, with *Cololejeunea harrisii*, *C. tanzaniae*, *Diplasiolejeunea zakiae*, *Drepanolejeunea madagascariensis* and many other species

*Fig. 10. Neorutenbergia usagarae* on the trunks of montane forest trees. NE ridge of Bondwa in the Uluguru Mts. at 1800 m alt.

especially in the Ulugurus: UKA: Mnyera ridge 2100 m (6740/AF, type locality of *Neorutenbergia armata* Bizot et Pócs, this collection also with sporophytes), Mnyera SSW 1950–2050 m (6742/V); ULU: Lupanga W 1650–2100 m (6071/AL, 6126/A, 6127/C); Lupanga SW 1700–1900 m (6258/CE); Lupanga — Kinazi ridge 1800–1900 m (6836/AU); Palata NW 1700–1890 m (6851/E, 6852/A, Mabberley 1147); Bondwa NE 1750–2100 m (6052/AT, 6537/G, 6579/F) (Mabberley 1147); N 1850–2000 m (6230/F); NW 1600–2000 m (6227/A); Mt. Tumbako S 1480–1530 m (6877/R); Magari peak E 2000–2100 m, top 2345 m (6297/Q, 6300/AH); Mt. Kifuru S 1875–2010 m (6914/E, 6915/H); Bunduki, Kikododo 1750–1900 m (6464/AG); Kibungo E 1700 m (6476/G); Lukwangule Plateau W 2400–2500 m, S 2500 m (6080/AH, 6825/F, S); det. P. The species is distributed in the West Usambara, Nguru, Ukaguru, Uluguru and in the Usagara Mountains, all of precambrian age, and does not occur in the area of tertiary volcanoes. See map and further discussion in Pócs (1975).

### Trachypodiaceae

75. **Trachypus appendiculatus** (Ren. et Card.) Broth. — On bark of sprayed trees near a waterfall. ULU: Hululu Falls, 1560 m (6910/B); det. B. Palaeotropic species, in continental Africa is known only from the Uluguru Mountains.

76. **Trachypus bicolor** Reinw. et Hornsch. var. **viridulus** (Mitt.) Zant. Syn.: *T. laetus* (Ren. et Card.) Fleisch. On wet rocks in montane forest and thicket. ULU: Bondwa N 1600 m (6050/AV); Hululu Falls 1470 m (6901/B); *RUN: Mt. Kyejo E of Tukuyu town, lava flow of the N slope, 1700 m (6770/D); det. B. Pantropical, EAB I.
77. **Trachypodopsis serrulata** (P. Beauv.) Fleisch. var. **crispatula** (Hook.) Zant. On bark in montane forest. *POR: Lake Ngozi crater rim E 2200–2250 m (6329/AU); det. P. Palaeotropic species (EAB I, IV); the var. crispatula is mainly Asian, previously known in Africa only from Nigeria and Cameroon.

### Pterobryaceae

78. **Pterobryon flagelliferum** Mitt. J. Linn. Soc. Bot. 22: 312 (1886). Syn. nov.: *Pterobryon julaceum* Broth. Bot. Jb. 10: 166 (1895). — Common epiphyte in submontane and in montane forest. WUS: Mazumbai U.F.R. 1500 m (6370/AW); Mazumbai, Kambo 1620 m (6374/AD); EUS: Hunga v. near Amani, 860 m (6378/N); *NGU: Above Kwamanga village, 1400–1500 m (6398/M); ULU: Mzinga v. 1400–1600 m (6290/AF); Nguru ya Ndege summit 1150–1300 m (6559/R); Mt. Kifuru 1875–1980 m (6914/H); Kilangala

*Fig. 11. Bryum keniae* on the ground of montane forests. Uluguru Mts., NE ridge of Bondwa, 1740 m

*Fig. 12.* Bamboo (*Arundinaria alpina*) forest on the outer slopes of Lake Ngozi crater in the Poroto Mts. at 2000 m altitude. On the nodes *Plagiochila lastii, Frullania serrata, Lepidopilum lastii, Floribundaria floribunda, Papillaria borchgrevinkii* and *Brachythecium duemmeri*

summit SE of Bunduki, 1750–1900 m (6464/BH); Mkungwe F.R. W 800–1100 m (6218/S); det. B. East African montane species restricted to the geologically old, crystalline areas — does not occur on the volcanoes.

79 **Jaegerina stolonifera** (C. Müll.) C. Müll. ssp. **laticuspis** (J. Taylor et P. Varde) G. Argent — Corticolous in submontane rain forest. ULU: Tumbako SE 1050 m (6167/AE); det. B. East African subspecies of a palaeotropic species, EAB I.

80. **Calyptothecium acutifolium** (Brid.) Broth. — On bark in montane forest, on rocks in spray effected riverine lowland forest. *POR: Igali pass, 1800 m (6749/C); Z: Victoria Falls, Palm grove, 800 m (6614/S); det. B. var. longiusculum (C. Müll.) Argent — *MER: Mt. Meru E 1800 m (coll. Szunyoghy 16/b); det. P. Distributed from Angola to S Africa and in Réunion, the variety is known from Cameroon, Ethiopia and from the Usambaras, EAB IV.

81. **Calyptothecium hoehnelii** (C. Müll.) Argent — Common corticolous epiphyte of montane forests. MER: Ngurdoto crater rim, 1800 m (6213/Q); *NGU: Mafulumula N, 1920 m,

W 1700–1800 m (6440/G, 6441/G); *UKA: Mt. Kifigo SE 1600–1800 m (6591/D, K, 6592/L); Mnyera E 1850 m, Mnyera ridge 2100 m (6870/B, 6740/AC); Mandege F. St. 1520 m (6869/B); Mamiwa West ESE 1800–1900 m (6863/E); Mt. Ikwamba 1700–1875 m (6865/W); ULU: Mwere v. 1550 m (6891/H); Bondwa N 1450 m (6270/A); Mgeta v. 1600–2250 m (6830/K, L, 6912/W); Lukwangule Plateau E 2250–2450 m (6827/AE, 6828/X); SHL: Mufindi Scarp F.R. near Fishing Camp, 1700 m (6322/M); Lupeme tea estate, 1800 m (6318/AK); behind Kilima tea factory 1725 m (6780/J, 6321/K, L); RUN: Small collapsed crater along the Mbeya — Tukuyu highway, 2000 m (6756/E, G)Mt. Rungwe E 2400–2500 m, SW 2100–2300 m (6503/Q, 6764/G); POR: Igali pass near Isangate, 1940 m (6748/F); det. B. Widespread East African species from Mt. Elgon to Cape, EAB I, IV.

82. **Calyptothecium planifrons** (Ren. et Card.) Argent Syn.: *Phyllogonium chevalieri* Corb. — Corticolous in montane forests. *WUS: Mazumbai U.F.R. 1500 m (6370/AV); *NGU: W of Kwamanga village, 1400–1500 m (6398/O); *ULU: Lupanga NW 1700–1800 m (6127/B); Bondwa NE 1740 m (6578/H); Kipengere Range in Southern Tanzania, 15 km NW of Njombe, Nyumbamtu, 1940 m (6754/F); Z: Mukowonshi Mt., 45 km NNE of Mpika, "mist forest", 1800 m (6629/O); det. B and P. Chad, Central African Republic, Zaire: Shaba, Zambia and Madagascar, uncommon.
83. **Hildebrandtiella pachyclada** Besch. — Corticolous, in submontane and in montane forests. EUS: Amani 900 m (6086/AW, 6100/A); *NGU: Mafulumula coll 1600–1800 m (6438/AC); N 1920 m (6440/K); ULU: Nguru ya Ndege N 900–1000 m (6448/R, U); Mt. Mindu 1200 m (6492/H, 6843/AB); Kinazi NW 1400–1650 m (6289/BA); Kinole sawmill 900–1000 m (6189/P); Mkungwe F.R. W 800 m (6217/E); Bondwa NE 1700–1850 m (6578/AZ, 6713/A); Mt. Kifuru E 1580 m (6905/Q); det. B. East African — Lemurian, EAB I, IV.
84. **Orthostichopsis subimbricata** (Hpe) Broth. Syn.: *Pilotrichella pilifolia* Dix. — Epiphyte in submontane and in montane forests. EUS: Amani, on the mango tree near Forest Houses, 900 m (6100/V); ULU: Bondwa NE 1740 m (6578/AJ, CJ); *SHL: Mufindi Escarpment, behind Kilima tea factory, 1725 m (6780/A); det. B. East African — Lemurian montane species, EAB I, IV.

## Meteoriaceae

85. **Squamidium biforme** (Hpe.) Broth. — Ct, ra and on bamboo stems in mist effected *Brachystegia* woodland, montane forests and elfin woodland. *KEN: Kamweti Track 2400–2700 m (6601/U, AA p.p.); WUS: between Magamba and Mabweni, 1900 m (6206/E) — fo. *chlorothrix*; ULU: Nguru ya Ndege N 900–1000 m (6448/S); *UKA: Mnyera ridge 2100 m (6871/AX); *KIP: Kitulo Plateau 2650 m (6750/AX); *RUN: Mt. Rungwe SW 2500–2600 m (6767/K); det. B. EAB I, IV.

85/A **Squamidium biforme** (Hpe.) Broth. var. **densirameum** (Broth.) Bizot **comb. nov.** Basionym: *Pilotrichella densiramea* Broth., Bot. Jahrb. 20: 197 (1894). Synonym: *Squamidium densirameum* (Broth.) Broth., Nat. Pfl. 1: 809 (1894). — Ramicolous in elfin woodland. *UKA: Mnyera ridge 2100 m (6871/AM); det. B.

86. **Pilotrichella ampullacea** (C. Müll.) Jaeg. — Common epiphyte of montane forests and elfin woodlands. MER: E 2000 m (6339/S); Ngurdoto crater rim, 1800 m (6213/E, P); KEN: Castle Forest St. 1960–2000 m (6603/K); *NGU: Maskat Mission, 1500 m (6444/E); *UKA: Ikwamba N 1875–1920 m (6866/X); Mamiwa E 2200 m (Mabberley 1389); Mnyera ridge and peak 2000–2100 m (6740/AB, AD, 6742/AB, 6871/G). ULU: Mgeta v. 2250 m (6830/M); *RUN: Mt. Rungwe N 2300 m, SW 2500–2600 m (6334/S, 6767/Z);

*Z: Mukowonshi Mt. NNE of Mpika, "mist forest" E 1800–1840 m (6629/W); det. B. Widespread from Central Africa to the Mascarenes.

87. **Pilotrichella cuspidata** Broth. — Ct and ra in montane forests. KEN: Kamweti Track 2400–2700 m (6601/AA); KIL: Mweka Route 2150 m (6344/AJ); *NGO: near Crater Lodge 2300 m (6196/J); *KAN: S 1100–1300 m (6139/AM); *UKA: Mt. Kifigo SE 1600–1760 m (6591/L, M); Mt. Ikwamba 1700 m (6865/L); Mamiwa West S 1900–1950 m (6863/C); near the falls along the road to Mandege F. St. 1200 m (6744/D); near Mandege F. St. 1500 m (6586/E); *RUN: on the slope of a small, collapsed crater along the Mbeya — Tukuyu road, SW 2000 m (6756/K); Mt. Rungwe NE 2400 m (6327/R); det. B. EAB I, IV.

88. **Pilotrichella isleana** Besch. — Epiphyte in submontane and in montane rain forests. KIL: Marangu Route 1900 m (6208/B); Umbwe Route 2100 m (6353/F); *ULU: Midhani, NE of Kinole village, 860 m (6880/Q, 6881/AG); Lupanga NW 1650–1700 m (6068/Z); det. B. EAB I, IV.

89. **Pilotrichella perrobusta** P. Varde — Ramicolous in elfin woodland. ULU: Lupanga — Kinazi ridge 1800–1900 m (6836/P); *UKA: Mnyera ridge 2100 m (6740/AE, 6871/AF); det. B and P. Lemurian species with tropical American affinities, see EAB I: 328, p. 433.

90. **Pilotrichella sericea** Kindb. *NGU: Mafulumula coll above Mnembule village, 1650–1800 m (6438/U, L); det. B. Known only from Kenya: Aberdare Mts., Leikipia.

91. **Papillaria africana** (C. Müll.) Jaeg. — Common epiphyte of montane forests. KEN: Castle Forest St. 2020 m (6602/M, O); NGO: Crater rim near the Crater Lodge, 2300 m (6196/G); MER: Njeku 2560–2650 m (6341/AN, 6521/F); KIL: coffee plantations N of Marangu 1500–1800 m (6209/D); above Mandara Hut 2800 m (6245/AE); Mweka Route 2725 m (6718/AU); Shira Route NW 2600 m (6355/U); *NGU: Maskat Mission 1500 m (6444/Q); *UKA: Mandege F. St. 1520 m (6586/B); ULU: Tumbako SE 1050 m (6264/D); Mt. Mindu top 1200 m (6843/D); SHL: Mufindi 1900 m (6320/R); Kilima Tea Estate 1725 m (6780/B); det. B. and P. Widespread in Southeast tropical Africa from Angola to Madagascar, EAB I, II, IV.

91/A **Papillaria africana** (C. Müll.) Jaeg. var. **flagellacea** Bizot **var. nov.** *A typo differt ramis flagelliferis Papillariae nigrescentis similis.* *UKA: Mandege Forest Station, secondary forest along streamlet at 1500 m, on bark. Coll. T. Pócs, B. J. Harris and P. S. Mwanjabe, 24. May 1972, No. 6586/B. Holotypus: EGR, Isotypus: PC. A conspicuous variety with fragile, flagelliform, naked or microphyllous branch tips, which are similar to those of *Papillaria nigrescens*, and serve, as propagulae.

92. **Papillaria borchgrevinkii** Kiaer — On spongy lava rocks and on bamboo stem in the montane forest belt. *RUN: Lava flow at the N foot of Mt. Kyejo E of Tukuyu, 1700 m 6770/E); Ngozi crater rim E 2100 m (6330/S); this species previously known from Madagascar and from the Uluguru Mts. is most probably conspecific with *Papillaria breviculifolia* C. Müll. described from Kilimanjaro Mts., from which it differs only by the dentition of the leaf margin. Det. and annotation by B.

93. **Aerobryidium subpiligerum** (Hpe.) Card. — Ct, ra and ph, rarely te in submontane and in montane forests and woodlands. *KEN: Castle F. St. 2000 m (6603/J); *Taita Hills: Mbololo Hill 1700–1800 m (R. B. Faden et al. 71/1020/W); KIL: Umbwe Route 1750–2600 m (6372/AV, 6373/J, 6786/E); *MER: Ngurdoto crater rim 1800 m (6213/J); *WUS: Magamba — Mabweni 1900 m (6206/D); EUS: Amani 900 m (6086/BA, BC); *NGU: above Kwamanga village 1400–1500 m (6398/N); *UKA: Mnyrea ridge and peak 1890–2100 m (6870/E, 6871/AY); ULU: Mindu Mt. 1200 m (6843/AA); Bondwa top 1800–

2100 m (6012/AK, 6261/P, 6233/X); SHL: Kilima Estate ESE 1725 m (6780/C); *RUN: Mt. Rungwe SW 1950–2050 m (6763/B); det. B. EAB I, II, IV.

94. **Floribundaria floribunda** (Doz. et Molk.) Fleisch. — Epiphyte (incl. epiphyllous) and on rocks in montane forests. *KEN: Castle F. St. 2000 m (6003/O); *UKA: Mnyera ridge NW 1800–1950 m (6743/J); Mandege F. St. 1520 m (6869/Y); Mamiwa West S 1900–1950 m (6863/F); ULU: Bondwa, slopes and top 1450–2130 m (6181/B, 6052/CB, 6578/BC, 6854/AE); Tumbako SE 1050–1390 m (6875/G); Kilangala 1750–1900 m (6464/BG); Mgeta v. 1600–2250 m (6830/Y, 6912/X); NGU: above Kwamanga village 1500 m (6398/L); Mafulumula W 1700–1800 m (6441/L). *SHL: Kilima Estate SSE 1725 m (6780/D); POR: Igali Pass 1800 m (6749/D); *RUN: Mt. Rungwe SW 1700–1800 m (6761/D); *Z: riverine forest below Kundalila Falls, SE of Kanona, 1425 m (6624/E). M. Bizot several times expressed his doubt, whether *Floribundaria cameruniae* Dus. is conspecific with *F. floribunda*, or not, due to the rarity of the sporophytes by the African specimens (Bizot and Pócs 1974: 433, Bizot et Dury 1978: 72). Finally Argent (1979: 189) solved the problem examining many sporophytes of both species and proved the identity of *F. cameruniae* with its earlier synonymon, *F. floribunda*, which is widespread accordingly both in tropical Asia and Africa. Annotation by P.

*Fig. 13. Podocarpus milanjianus — Erica* arborea forest on Mt. Kilimanjaro at 2700 m altitude, with large cushions of *Herbertus, Dicranoloma billardieri, Lepidozia cupressina, Plagiochila barteri*, etc.

*Fig. 14.* Corticolous bryophyte community on *Erica arborea* bark in a giant heath on Mt. Kilimanjaro, at 2400 m alt., with *Plagiochila subalpina*, *Adelanthus decipiens*, *Chandonanthus hirtellus*, *Drepanolejeunea friesii*, *Lophocolea lucida* and *Frullania lindenbergii*

95. **Floribundaria patentissima** (C. Müll.) Fleisch. — Epiphyte in montane forests. *UKA: Mt. Ikwamba NW 1680 m (6865/AC); ULU: Manga E 1150–1250 m (6225/E); SHL: Kilima Estate 1725 m (6780/H); RUN: Mt. Rungwe SW 2400 m (6765/B); det. B. EAB I.

95/A **Floribundaria patentissima** (C. Müll.) Fleisch var. **squarrosa** Ren. et Card. — *ULU: Mt. Mindu S 1170–1275 m (6492/J); Nguru ya Ndege E 950–1050 m (6457/K); *SHL: Kilima Tea Factory 1900 m (6321/N); Mufindi Lake 1800 m (6324/F); det. B. EAB I.

**Phyllogoniaceae**

96. **Catagonium nitens** (Brid.) Card. — Mostly on shady granitic rocks in montane forests, sometimes on bark or on tree fern stem. *UKA: near Mandege Forest St. 1540 m (6737/X); ULU: Bondwa-Luhungu 1600–1800 m (6228/A); all sides of Lupanga peak 1500–1900 m (6547/P, 6285/CW); Magari peak 1500–1800 m (6296/X); det. B and P. EAB I.

*Fig. 15.* Mossy forest of *Hagenia abyssinica* and *Erica arborea* at 2800 m altitude on Mt. Kilimanjaro just below the forest line. On the ground *Hylocomium splendens*, *Campylopus jamesonii*, *Leptodontium luteum*, *Thuidium matarumense*, *Bryum leptoneurum*, *Brachymitrion pocsii*, *Plagiochila boryana* and others

*Fig. 16.* Upper margin of the relatively dry *Hagenia–Podocarpus–Dombeya–Lasiosiphon* forest on the Kitulo Plateau (Kipengere Range) at 2700 m alt., with dominancy of *Usnea pseudoceratina*, *Porotrichum comorense*, *Plagiochila divergens*, *Frullania caffraria*, *Neckera remota* and *N. submacrocarpa*, *Macrocoma tenue* and *Rhizofabronia perpilosa* on the bark of trees. In the foreground grassland abundant *Pogonatum oligodus* and *Funaria volkensii*

### Neckeraceae

97. **Neckeropsis lepineana** (Mont.) Fleisch. – On rocks and on barks in lowland and submontane rain forests. EUS: Amani near Forest Houses 900 m (6107/H); Ngurue valley E of Chemka village, 500–600 m (6516/G); ULU: Midhani, NE of Kinole village, 860–1300 m (6875/F, 6879/A); Manga E near Mgolole 1100 m (6223/N); *NGU: W of Mhonda Mission, 800–1000 m (6400/U); det. DE SLOOVER and P. Palaeotropic species, EAB I.
98. **Homaliodendron exiguum** (Bosch. et Lac.) Fleisch. – Ramicolous, epiphyllous or on shady rocks in montane forests. *NGU: near a stream below Mnembule village, 1400 m (6437/GB); *ULU: Mwere v. 1500–1600 m (6176/BK); Bondwa N above Morningside, 1450 m (6854/E); det. P. Madagascar, Réunion, Indomalaysia – Oceania. New for continental Africa. In fact, its var. *semimarginatum* (Thér.) W. Sch.-Mot. is known from West Africa. By the kindness of the director and curator of PC I was able to study the type specimen of this variety, which was collected in Liberia, Gbanga during 1926. It did not contain any plantlet belonging or related to *Homaliodendron exiguum*, but consisted

*Fig. 17.* The interior of a mossy elfin woodland on Bondwa peak in the Uluguru Mts., at 2200 m alt. Very rich bryophyte habitat, among others with *Bazzania borbonica, Paraschistochila englerana, Chiloscyphus decurrens, Conoscyphus trapezoides, Pleurozia gigantea, Pilotrichella perrobusta* and *Syrrhopodon stuhlmannii*
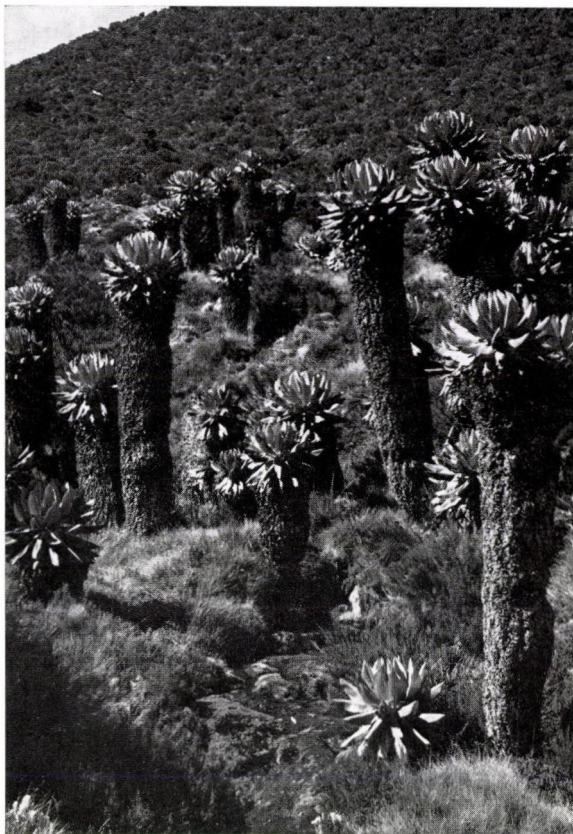
*Fig. 18.* Giant Senecio moorland above Horombo Hut, Kilimanjaro Mts. at 3800 m alt. Typical habitat of more hygrophilous afroalpine bryophytes, as *Hygrohypnum hedbergii, Drepanocladus uncinatus, Campylopus stramineus, Philonotis tomentella*

of a very confusing mixture: a few shoots of the moss *Neckeropsis disticha* (Hedw.) Kindb. fully intermixed with the rare liverwort *Stictolejeunea balfourii* (Mitt.) E. W. Jones — both being new to the flora of Liberia. This mixture probably misguided THÉRIOT, the leaf shape of *Stictolejeunea* being similar in outline to *Homaliodendron exiguum,* while the areolation of *Neckeropsis,* being slightly different from *Homaliodendron,* supplied the distinction for the description of a new variety. While the new epithet was applied to a mixture, of which both components were previously described, a lectotypification procedure is not necessary and the name of var. *semimarginatum* should be simply rejected. Annotation by P. **Nomina reiicienda:** *Homalia exigua* Bosch et Lac. var. *semimarginata* Thér., Rev. Bryol. n. ser. 3: 47 (1930); *Homaliodendron exiguum* (Bosch et Lac.) Fleisch. var. *semimarginatum* (Thér.) W. Sch.-Mot. Willdenowia 7: 505 (1975).

99. **Pinnatella flagellacea** (Mitt.) Broth. — On bark, sometimes on rocks in submontane and in montane forests. EUS: Chemka village, 600 m (6382/B); *NGU: above Mnembule village 1650–1800 m (6438/AA); *ULU: Nwere v. 1400–1600 m (6158/AG); W of Kibungo Mission, 1500–1700 m (6475/AC); *RUN: small, collapsed crater S of Isongole, 2000 m (6756/C); det. B. EAB IV.

100. **Pinnatella oblongifrondea** (Broth.) Broth. — Corticolous (mostly on butresses) in lowland and in submontane rain forests. EUS: E of Chemka village, 5–600 m (6516/N); Sigi v. 500 m (6294/F); Amani 900 m (6107/B); *NGU: Mhonda Mission W 800–1000 m (6400/M); near Kombola village 900–1200 m (6436/H); ULU: Midhani, along Mzuazi stream, 845 m (6882/C, D); Tumbako SE 1050 m (6167/AA); Manga E 1100 m (6223/H), N of Kinole village, 1000 m (6471/B); Bondwa N 1450 m (6854/AF); det. B. Cameroon, Gabon, Congo Republic, R.C.A., K: Kakamega F., Tanzania.
101. **Pinnatella tamariscina** (Hpe.) Broth. — Corticolous in submontane and in montane rain forests. ULU: Kinole sawmill 1100 m (6874/L); above Simbini village 1400–1500 m (6418/AE); Bondwa NE 1740 m (6578/BY); Palata 1700–1850 m (6851/F); It is very closely related to *P. flagellacea* (Mitt.) Broth., differs only by its leaf shape. Det. and annotation by B. Cameroon, Tanzania, Mascarenes.
102. **Porotrichum comorense** Hampe ex C. Müll. — Epiphyte, rarely on shady rocks in submontane and in montane rain forests. KIL: Marangu Route 1800–2000 m (6208/G, 6364/M); *WUS: U.F.R. near Mazumbai 1600–1750 m (6371/AE); *NGU: Mafulumula coll above Mnembule village, 1650–1800 m (6438/T, V); W of Mhonda Mission 800–1000 m

*Fig. 19.* Corticolous community on *Senecio cottonii* trunk in the Barranco valley, Kilimanjaro Mts., at 4000 m alt., with *Tortula cavallii*, *Bryoerythrophyllum rubrum*, *Orthotrichum rupestre* and *Brachythecium afroglareosum*

*Fig. 20.* Dry, semidesertic lava rocks near the previous locality near Barranco hut at 3900 m alt. On the exposed surface *Marsupella africana* and *Andreaea mildbraedii*, in sheltered crevices *Diplophyllum africanum* and *Gymnomitrion laceratum*. All habitats were photographed by T. Pócs

(6400/K, N); *UKA: Mamiwa West SE 1800–1900 m (6862/D); *ULU: Lupanga SW 1700–1900 m (6285/BW); Bondwa N 1900–2050 m (6599/C, 6120/GA); Luhungu W 1500 m (6263/F); Midhani 880 m (6880/G, 6881/B); *SHL: Kilima Estate, SSE edge of Mufindi Escarpment 1725 m (6780/F); *KIP: E of Igoma 2575 m (6511/L); Kitulo Pl. 2650 m (6750/K), det. B. Widespread in tropical Africa from Fernando Poo to Zimbabwe and Malawi.

102/A **Porotrichum comorense** (Hpe.) var. **flagelliferum** P. Varde — *KIL: Mweka Route 2800 m (6718/A); *ULU: Mt. Kifigo SE 1600–1750 m (6591/R); *POR: Lake Ngozi Crater rim 2200 m (6329/BV); det. B.

103. **Porothamnium hildebrandtii** (C. Müll.) Fleisch. — In most cases on shady rocks in submontane and in montane forests. KIL: Umbwe Route 2890 m (6211/G, 6718/CK); Mweka Route 1800–1900 m (6211/G); WUS: Magamba — Mabweni 1850 m (6205/D); ULU: Lupanga SW 1500–1700 m Kinole sawmill 1000 m (6166/G); Bondwa N, NE 1800–2000 m (6012/AV); Magari NNE 1500–1800 m (6296/S); above Simbini village 1400–

1500 m (6418/AL); Maunga v. above Mzinga, 1500 m (6263/G); *Kundalila Falls SE of Kanona, 1430 m (6623/J, 6624/D); det. B. EAB I.

104. **Porothamnium molliculum** (Broth.) Fleisch. — Epiphyte, sometimes on rocks in montane forests. KEN: below Castle For. St. 1860–2000 m (6603/L); KIL: Shira Route 2600 m (6355/S); *WUS: Magamba — Mabweni 1850 m (6205/C); *NGU: Dunema ridge above Kwamanga village, 1400 m (6398/K); near a stream by Mnembule village, 1400 m (6437/G); *UKA: Mt. Ikwamba N 1870–1920 m (P. LAWRENCE 6866/M); *ULU: Lupanga WNW 1900–2050 m (6550/M); Kinazi N 1800–1900 m (6837/E); Palata NW 1850–2000 m; Bondwa top 2000–2130 m (6120/GB, 6889/W); det. B. Afromontane species known from Cameroon, Ruwenzori, Kenia, Meru and from Kilimanjaro Mts.

105. **Porothamnium pennaefrondeum** (C. Müll.) Card. in Grand. Hist. Madag. 39: 377 (1915). Basionym: *Porotrichum pennaefrondeum* C. Müll. Linnaea 42: 409 (1876). Syn. nov.: *Porotrichum subpennaeforme* C. Müll. Flora 73: 488 (1890). The species is not synonymous with *Porotrichum comorense* C. Müll. nore with *Porothamnium hildebrandtii* (C. Müll.) Fleisch. as it was treated by SIM, Trans. R. Soc. S. Afr. 15: 402 (1926). — KIL: Umbwe Route 2200–2850 m (6787/J, 6192/Q); Mweka Route 2570–2750 m (6718/CU, CX, CW); ULU: Bondwa N 1900–2050 m (6051/FB, 6403/AJ); *RUN: Mt. Rungwe ENE 2400–2500 m, SW 2400 m (2503/P, 6765/D); annotation and det. B. East African mountains, Angola, South Africa and Mascarenses.

### Lembophyllaceae

106. **Rigodium kilimandscharicum** (Broth.) Par. — Epiphyte in montane forests. KIL: Umbwe Route 1700–1900 m (6351/S); Marangu Route 1900–2200 m (6364/K); ULU: Lupanga S 1750 m (6468/B); Kinazi N 1800–1900 m (6837/D); det. B. and P. East African montane species, from Kilimanjaro to Transvaal.

### Pilotrichaceae

107. **Chaetomitrium dusenii** C. Müll. var. **brevinerve** (P. Varde) P. Varde — On bark in submontane rain forest. *EUS: Amani, behind the Forest Houses and in Sigi valley, 900–950 m (6377/L, 6513/A); det. B. Lowland forest element known only from West and Central Africa, and from Amani. EAB IV.

### Daltoniaceae

108. **Daltonia angustifolia** Doz. et Molk. var. **strictifolia** (Mitt.) Fleisch. — On giant *Senecio* stem at the forest line. *Abe: Gikururu v. 1.5 km W of Kiandogoro Gate, 2950 m (MABBERLEY 327/B); det. B. Palaeotropic species, EAB I.

109. **Daltonia cardotii** Biz. et Onr. Syn.: *Daltonia intermedia* Ren. et Card. hom. illeg. Epiphyllous in montane rain forest and in elfin woodland. *ULU: Bondwa E and top, 1600–2100 m (6181/AU, 6233/L); det. P. New for East Africa, previously known only from Cameroon and from Madagascar.

110. **Daltonia mildbraedii** Broth. in Mildbr. var. **levis** Dem. et Leroy — Epiphyllous in montane rain forest and in elfin woodland. *ULU: Mwere v. 1500–1600 m (6176/AL); Lupanga S 1900–2000 m (6287/AJ); det. P. East African montane species.

111. **Daltonia minuta** Thér. — Epiphyllous in montane forest. *ULU: Mwere v. 1500–1600 m (6168/AS, specimen preserved only in the form of microslide); det. P. Previously known only from Ninagongo volcano.

112. **Leskeodon mniifolium** (Hornsch.) Bizot — Epiphyllous in montane forest. ULU: Bondwa 1900–2100 m (6051/DC, 6233/AC); det. P. EAB I.
113. **Distichophyllidium africanum** Dem. et P. Varde — Epiphyllous in montane mossy forest. ULU: Bondwa 2000 m (6051/DE); det. P. EAB I.
114. **Lepidopilum dusenii** C. Müll. — Ramicolous in bamboo forest. ULU: Mgeta v. 2250 m (6830/P); det. P. EAB I.

### Hookeriaceae

115. **Calyptrochaeta asplenioides** (Brid.) Crosby — On shady rocks in montane forest. ULU: Mt. Kinazi NW 1630 m (6289/BM); det. P. Burundi, Uluguru Mts., Cape, Madagascar, Réunion, Mauritius.
116. **Cyclodictyon aubertii** (P. Beauv.) O. Kuntze — On thallus of Dumortiera hirsuta in wet montane forest. *ULU: Kinazi NW 1630 m (6289/BL); det. P. Previously known only in Kivu, area, Madagascar and in Mauritius.
117. **Cyclodictyon borbonicum** (Besch.) Broth. — Intermixed in moss cushions on wet rocks of *Erica* forest. KIL: Umbwe Route 2850 m (6788/CR); det. P. East African mountains from Ruwenzori to Réunion.
118. **Callicostella perpapillata** Broth. et P. Varde — Epiphyllous in montane forest. *ULU: Mwere v. — Bondwa 1600 m (6181/BD); det. P. Previously known only from West and Central Africa and from Uganda.
119. **Callicostella usambarica** (Broth.) Broth. — Epiphyllous and lignicolous in montane forest. *KIL: Umbwe Route 1900–2200 m (6191/AJ) p.p. ULU: Bondwa E 1600 m (6181/CK); det. P. Gabon, Central African Republic, Usambaras, Uluguru Mts.
120. **Lopidium hemiloma** (C. Müll.) Fleisch. — On bark and on rocks in submontane rain forests. EUS: Amani 900 m (6086/AZ); Hunga v. 880 m (6514/J); *NGU: Mhonda Mission W 800–1000 m (6400/O); *ULU: Manga E 1100 m (6223/F, G); Tegetero Mission 1100–1300 m (6426/B); Bondwa N 1450 m (6864/F); det. B. Previously known only from Amani and from the Comoro Islands.
121. **Lopidium struthiopteris** (Brid.) Fleisch. — On tree fern stems, rotting wood and on shady rocks in montane forests. *ULU: Lupanga WNW 1650–2050 m (6068/AA, 6550/K, 6065/Q); Mwere v. 1500 m (6220/J, 6255/F); Bondwa N 1900–2050 m (6308/Q); Kilangala summit SE of Bunduki 1750–1900 m (6464/BK); det. B. Palaeotropic species previously known only from Indomalaya-Oceania and Réunion Island

121/A **Lopidium struthiopteris** (Brid.) Fleisch. var. **campenonii** (Ren. et Card.) Bizot **stat. nov.** Synonym: *Lopidium campenonii* (Ren. et Card.) Fleisch. Musci Fl. Buitenzorg 3: 1073 (1908); Basionym: *Hypopterygium campenonii* Ren. et Card. in Ren., Rev. de Bot. 9: 400 (1891). Epiphyllous, corticolous and on tree fern stem in montane forests. *KEN: Castle For. St. 1960 m (6603/G); *WUS: Mazumbai U.F.R. 1600–1750 m (6371/AC); *UKA: Mnyera NNE 1900–2100 m (6739/J); *ULU: Kinazi NW 1400–1650 m (6289/BB), Mgeta v. 2250 m (6830/AP); Bondwa E 1600 m (6181/CH); det. B. The var. was known previously only from Madagascar.

122. **Lopidium subtrichocladon** (Broth.) Fleisch. — Epiphyte in montane forests. WUS: Mazumbai University Forest Reserve 1500 m (6370/AK); *UKA: Mt. Kifigo SE 1600–1760 m (6591/E); *ULU: Lupanga NW 1800–2000 m, WNW 1900–2050 m (6130/AG, 6550/H); Mt. Kifuru E 1580 (6905/M); *NGU: Mafulumula W 1700–1800 m (6441/F); det. B. Previously known only from Sao Tomé and from Usambara Mts.
123. **Hypopterygium mildbraedii** Broth. — Epiphyte and on shady rocks in montane forests. KIL: Shira Pl. NW 2600 m (6355/L); Umbwe Route 2100 m (6353/B); Marangu — Old Moshi 1700–1800 m (6368/X); *WUS: Mazumbai U.F.R. 1500 m (6370/AF); *EUS:

Ngurue v. E of Chemka 500–600 m (6516/M); *NGU: Mafulumula W 1700–1800 m (6441/K); ULU: Midhani 860 m (6879/J); Kinazi NW 1400–1650 m (6289/BC); Bondwa N 1500–1800 m (6050/AR, 6854/N); det. B. East African mountains from Ethiopia to Tanzania.

124. **Hypopterygium viridissimum** C. Müll. — Epiphyte and on rocks and ground of montane forests. KIL: Weru-Weru v. near Kissereni, 1260 m (6345/G); Mawingo Estate 1350 m (6349/R); Marangu Route 1850–1900 m (6208/E); WUS: U.F.R., Kambo 1620 m (6374/AS, Z); *NGU: Mafulumula W 1700–1800 m (6441/Q); *UKA: Mamiwa West S 1800–1900 m (6862/E); ULU: Lupanga NW and crest 1800–2100 m (6130/AG, 6550/L, P); Palata NW 1850–2000 m (6852/N); Bondwa N 1600–1800 m (6050/AU); det. B. Widespread in tropical America and Africa. EAB I, II.

### Fabroniaceae

125. **Anacamptodon africanus** P. Varde — At the edge of a knothole (2 cm diameter) on a trunk in lowland rain forest. *ULU: Kimboza Forest Reserve near Mkuyuni, 350–450 m (6800/V); det. B. Typical lowland forest element previously known only from the Central African Republic near Oubangui.

126. **Fabronia abyssinica** C. Müll. — Corticolous in miombo woodland and in *Velloziaceae* bush. *KIB: main summit SSE 1800 m (6566/N); Z: Lusaka East, Chalimbana River valley 1330 m (Kornaś 5/B, 10/A); det. B. Ethiopia, Southeast Africa from Zambia to Cape.

— **Fabronia bizotii** Pócs **stat. et nom. nov.**

Syn.: *Fabronia pocsii* Bizot var. *cameruniae* Bizot, Acta Bot. Acad. Sci. Hung. 19: 16 (1973). M. Bizot has described in the same paper two peculiar *Fabronia* taxa, which in general appearence were very similar to the members of the genus *Rhizofabronia* with the long dentition of the leaves and soft texture of their stems, but, on the other hand, their leaves had *Fabronia* like costa and basal group of quadrate cells. He described both taxa from the collections made by D. Balázs, one of them from Ethiopia, the other from Mt. Cameroon. The Ethiopian taxon, with mature sporophytes, received the name of *Fabronia pocsii*, while the other one, collected on Mt. Cameroon, with immature sporophytes, was described, as *F. pocsii* var. *cameruniae*, not differing much in vegetative characters from the Ethiopian plant.

The junior author recently received an unnamed *Fabronia* species collected by E. W. Jones from Mt. Cameroon, not far from the type locality of *F. pocsii* var. *cameruniae* Bizot. The specimen corresponds in all aspects to the above variety and in addition bears many mature sporophytes. The sporophytes differ considerably from those of *Fabronia pocsii* from Ethiopia, and these differences give ground to raise var. *cameruniae* at a species level. While one *Fabronia cameruniae* C. Müll. ex Dus., Svensk Vet. Ak. Handl. 28: 54 (1895) is already described and corresponds to an other taxon, the allocation of a new name is necessary. The junior author considers it to be an honouring opportunity to commemorate the name of his late friend and co-author

dedicating this species to him. A distinction between the morphological and anatomical features of the two concerned species is given below (see also the figs):

**Fabronia pocsii** Bizot

Capsule urn shaped, 1.5–2 × longer, than wide, more, than 1 mm long. Exothecium cells are more or less elongate, their outer wall is thick, only slightly convex. Peristomium rudimentar. Spores 17–21 μm in diameter of seta at its base 120–130 μm.

**Fabronia bizotii** Pócs

Capsule bell shaped, as wide or wider than long, its length only about 0.5 mm. Exothecium cells isodiametric or irregular in shape, their outer wall relatively thin, hemispherically bulging. Peristomium consists of 16 paired, papillose, regular exostomium teeth. Spores 10–13 μm in diameter. Seta diameter only 60–70 μm.

*Fig. 21.* Sporophytes of *Fabronia pocsii* Bizot, type. Phot. G. Kis
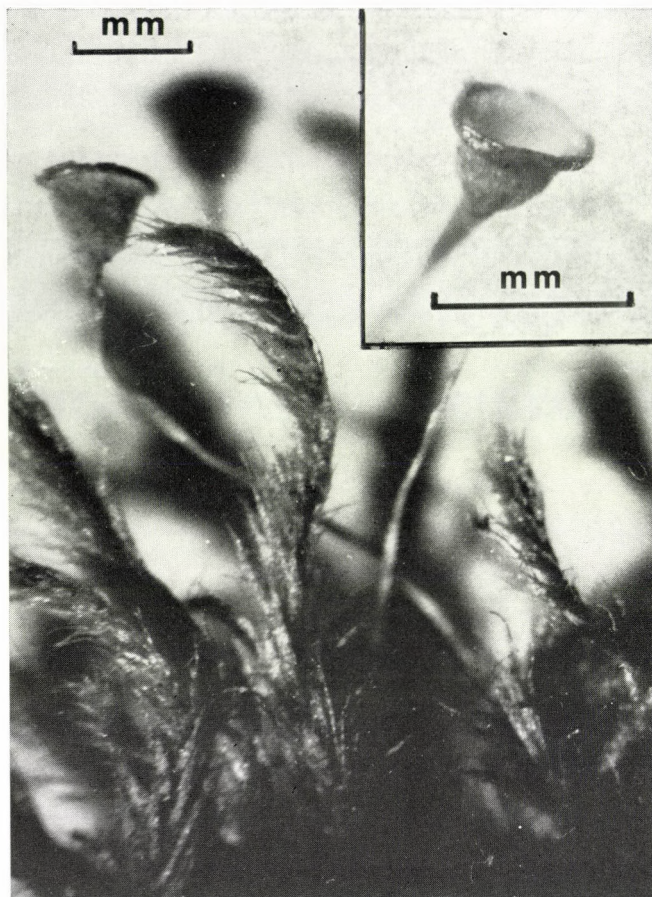
*Fig. 22.* Sporophytes of *Fabronia bizotii* Pócs, paratype. Phot. G. KIS

The seta length varies between 3 and 6 mm by both species, and the perichaetial leaves, although smaller, are similar to the stem leaves, *F. pocsii* possessing smaller, shorter, and *F. bizotii* longer, ciliate teeth. It seems to be useful to publish full locality records on both species:

**Fabronia bizotii** Pócs — Mt. Cameroon, S slope, in a lava cave above the timberline, at 2900 m alt. coll. D. BALÁZS No. 79/b, 27. Nov. 1967. (Type of *F. pocsii* var. *cameruniae* Bizot ex Pócs, Holotype EGR, Isotype PC.) Mt. Cameroon, S slope, Ukile, tree boughes at tree line. Alt. 8400 feet (±2530 m). Coll. E. W. JONES s. n., April 1948, during the Cambridge Botanical Expedition in the British Cameroons. (Paratype of *F. bizotii* Pócs, which served for the description of its sporophyte, EGR and Hb. E. W. JONES.)

**Fabronia pocsii** Bizot — Ethiopia: Mountains W of Addis Ababa, near the Lake Debre Zeit, on bark, at 1800–2400 m alt. Coll. D. Balázs No. 111/AH, 9. March 1968. (Holotype PC, Isotype EGR.)

127. **Fabronia longipila** Broth. — On bark of trees in dry savanna woodlands, of roadside and of park trees, sometimes on dry rock faces. *K: Nairobi, Ainsworth Hill park (6608/A); KIL: Sanya Juu 1280 m (6356/A); Mawingo Estate near Mweka, 1350 m (6350/C); *UKA: Mandege For. St. 1520 m (6593/C); *KIB: NE face of the main peak, 1900–2000 m (6569/N); ULU: Morogoro, along Boma road, 525 m (6142/E); Bahati Camp 600 m (6561/M); *Z: 12 km E of Lusaka, 1300 m (6609/L); 30 km NE of Choma (6612/A); det. B. Known in East Africa from Uganda to Tanzania.
128. **Fabronia pilifera** Hornsch. — Ecology, as of the above species. *KEN: Castle For. St., near the building, 2020 m (6602/G); Nairobi NE (6607/D); *NGU: in coffee plantations near Kwamanga village, 100 m (6396/G); ULU: Kikundi above the University Campus, 900 m (6428/A); Mindu E ridge 900 m (6841/F); Nguru ya Ndege 900–1000 m (6448/Q); Tegetero Mission 975 m (6424/AD); Bunduki Fishing Camp 1250 m (6906/B); Mgeta v. 1250 m (6908/E); det. B. More widespread, than the preceding species, known from Angola and from Zaire to Cape.
129. **Rhizofabronia persoonii** (Schwaegr.) Fleisch. var. **sphaerocarpa** (Dus.) Bizot — 23 out of 27 specimens from tree fern stem, twice on bark of other trees or shrubs, once on shady rock, and once on soil of roadcut surface in montane rain forests and in elfin woodland, between 1500 and 2400 m alt. *UKA: Mt. Kifigo SE 1760–1850 m (6592/O); Mnyera NNE 1900–2100 m (6739/K); Ikwamba N 1875–1920 m (6866/B); ULU: Bondwa, all sides from 1500 to 2100 m, 11 records, Mwere v. 1450–1700 m, 5 records; Palata E 1850–1900 m (6852/O); Magari 2000–2100 m (6297/S); SE of Bunduki, Kilangala top 1750 m (6464/BM); Mgeta river v. 1700–2250 m (6912/T, 6830/S); Mt. Kifuru S 1875–1980 m (6914/D); *RUN: Mt. Rungwe SW 1700–1800 m (6778/K); det. P. Afromontane element restricted to moist forest regions of Cameroon and of East Africa from Ruwenzori to Malawi: Nyika Plateau.
130. **Rhizofabronia perpilosa** (Broth.) Broth. — The ecology of this species differs considerably from that of the previous one. It grows either on lava rocks, usually in small holes or in greater "caves" above the timberline or on bark in the forest belts, but always in drier habitat. It prefers the higher branches and parts of trunks of trees in mesophilous or relatively dry montane forests, and never occurs on tree ferns in true rain forests. Its ecology on Mt. Cameroon is discussed by Richards and Argent (1968: 584), its distribution is mapped by Bizot et al. (1979: 162). The junior author discovered it in the lava cavities of Mt. Kilimanjaro too, up to 3900 m altitude: Umbwe Route, IInd Bivouac, 3330 m (6932/C); IIIrd Bivouac near Barranco Hut, 3900 m (6935/A); in a lava cave near Shira Hut, 3660 m (6927/AA). The following records are from forest habitats: MER: E 2800 m (6522/B); Kitoto 2400 m (6520/K); *POR: E of Igoma, S 2575 m (6511/N); *RUN: Mt. Rungwe E, 2400–2500 m (6503/L); *KIP: Kitulo Plateau, NW edge, 2650 m (6750/V); det. P. It seems to be an endemic species of the high African volcanoes, between 2000 and 4000 m alt. of Mt. Cameroon, Mt. Elgon, Aberdare, Ninagongo, Mt. Meru, Mt. Kilimanjaro and of the above new localities.
131. **Schwetschkea schweinfurthii** C. Müll. — Corticolous in dry evergreen forest. *T: Pongwe hills in Bagamoyo Distr., 430 m (6145/N); det. B. Known only from Central Africa.
132. **Schwetschkea usambarica** Broth. — Corticolous in mesophilous montane forests. *ULU: near Morningside, 1420 m (6414/N); *Z: forest fringe above Kundulila Falls near Kanona, 1490 m (6626/C); det. B. Previously known only from Usambara Mts.

### Regmatodontaceae

133. **Regmatodon secundus** Kiaer — Corticolous and sometimes on rocks in montane forests. *KEN: Castle Forest St., 2020 m (6602/J, N, LA); *NGU: Mt. Mafulumula W between Mnembule and Maskat, 1700–1800 m (6441/J); *ULU: Bondwa NE 1580–1800 m (6781/B, 6573/M); *POR: Lake Ngozi crater, inner slope 2100 m (6775/A); det. B. Afromontane species known from Guinea and Fernando Poo to the Mulanje Mts. in Malawi.

### Leskeaceae

134. **Hylocomiopsis cylindricarpa** Thér. Rev. Bryol. Lichénol. 3: 40 (1930). Syn. nov.: *Pseudoleskea dispersa* C. Müll. Bot. Jahrb. 24: 282 (1897). In EAB I, under the latter name (No. 375) we recorded this species from S Tanzania. Further Tanzanian localities, where it lives, as corticolous moss in montane forests: MER: Njeku 2600 m (6520/B); *NGU: Mafulumula W 1700–1800 m (6441/H); RUN: S of Isongole, along Mbeya — Tukuyu highway, 2000 m (6756/J); Mt. Rungwe SW 1800 m (6777/AF); det. B. Afromontane, Cameroon and from Ethiopia to Tanzania.
135. **Pseudoleskea leskeoides** (Par.) C. Müll. var. **macowaniana** Thér. — Corticolous in dry Acacia savanna. *KIL: Sanya Juu 1280 m (6356/B). The variety is known only from South Africa: Cape, Natal, Transvaal.

### Thuidiaceae

136. **Haplocladium angustifolium** (Hpe. et C. Müll.) Broth. — Corticolous in relatively dry montane forests or on sole trees. *KIL: Shira Route, above Wasendo Glade, 2700 m 6354/J); Ghona v. near Makom, W of Marangu 1400 m (6366/B); ULU: Chenzema Mission 1700 m (6812/R); det. A. Touw. S Eurasia, Australasia, Africa see in EAB I.
137. **Haplohymenium pseudotriste** (C. Müll.) Broth. — On bark and on limestone rocks in lowland and in submontane rain forests. *EUS: Amani, near Forest Houses, 920 m (6376/G); *ULU: Kimboza F. R. near Mkuyuni, 350–450 m (6800/N); det. B and Touw. SE Asia, Australasia, S Africa, Mauritius, new for East Africa.
138. **Herpetineuron toccoae** (Sull. et Lesq.) Card. — Corticolous in relatively dry montane forest. *MER: Ngurdoto Crater rim, 1800 m (6213/K); det. B. Pantropical, EAB IV.
139. **Pelekium velatum** Mitt. — The records of *Thuidium involvens* (Hedw.) Mitt. in EAB I: No. 378 (Bizot and Pócs 1974: 438) refer to this species (cf. Touw 1976: 185). The genus then was new for Africa, widespread in Indomalaya and in Oceania.

### Amblystegiaceae

140. **Cratoneuron filicinum** (Hedw.) Spruce — On the ground of spring bog with *Senecio cottonii* stand. KIL: behind Barranco Hut, 3950 m (6796/A); det. B. Holarctic species with sporadic southern localities. In tropical Africa only in afroalpine habitats of Ruwenzori, Kenia and Kilimanjaro.
141. **Drepanocladus uncinatus** (Hedw.) Warnst. — In same habitat, with the preceding species. KIL: Umbwe Route, behind Barranco Hut, 3950 m (6796/C, 6933/JB); Marangu Route 3440 m (6247/O). EAB I.
142. **Drepanocladus** cf. **aduncus** (Hedw.) Warnst. — Submerged in 3 m deep water of papyrus swamps. *K: Lake Naivasha, Merrel's lagoon, 1890 m (Coll.: J. J. Gaudet, 3. Oct. 1974); det. P. A very peculiar modification or a new species obtained for naming from Nairobi University Herbarium. *Drepanocladus aduncus* was not known from tropical Africa.

143. **Hygrohypnum hedbergii** P. Varde — On irrigated basaltic rocks. KIL: Barranco Hut, 3850 m (6794/B, D); det. B. Afroalpine species, known only from Ruwenzori, Kenia and Kilimanjaro.

**Brachytheciaceae**

144. **Brachythecium afroglareosum** (Broth.) Par. — On bark (incl. giant *Senecios*), rocks and on soil of montane forests, giant Erica heath and of giant *Senecio* stands. KIL: Umbwe Route 3380–4000 m (6932/W, 6933/C); *NGU: near Mnembule village, 1400 m (6437/E); *UKA: Mandege F. Sz. 1730 m (6861/E); Mamiwa West S 1900 m (6863/D); *ULU: Bondwa N 1500 m (6854/V); Chenzema Mission 1700 m (6812/J); Lukwangule Plateau E 2300 m (6828/T); *POR: Igali Pass 1940 m (6748/C); *KIP: Kitulo Plateau E of Igoma, 2650 m (6750/AA); *RUN: E of Rungwe village near the TTC tea nursery, 1500 m (6759/C); det. B. East African montane species from Ethiopia to Tanzania.
145. **Brachythecium borgenii** (Hpe.) Jaeg. Syn.: *B. atrotheca* (Dub.) Besch. — On bark, rocks and on roadcut surface in the montane forest belt. ULU: Bondwa NW 1600–1800 m (6050/AB, AW); Lukwangule Pl. E 2300 m (6828/W); Chenzema Mission, 1700 m (6812/N); *POR: Igali pass near Isangate, 1940 m (6748/D); *RUN: SW of Rungwe village, 1450 m (6760/A); det. B. East African montane species, from Ethiopia to Tanzania and to Réunion.
146. **Brachythecium dummeri** Dix. — On bark and on rocks in montane forests. *KIL: Kikafu gorge near Kyere village, 1500 m (6347/E); *NGU: Maskat Mission, 1500 m (6444/L); *UKA: Mandege For. St., near Rubeho road, 1450 m (6587/C); *ULU: above Morningside, 1480 m (6885/B); POR: Igali Pass, 1800 m (6749/B); det. B. East African montane species from Mt. Elgon to Southern Tanzania, up to 4600 m altitude.
147. **Brachythecium gloriosum** (C. Müll.) Kindb. — On bark of *Nuxia congesta* trees in bamboo thicket. *KEN: Kamweti Track, 2400–2700 m (6601/Y); det. B. East African montane species known from Ethiopia and from Mt. Kilimanjaro.
148. **Brachythecium nigro-viride** (C. Müll.) Kindb. — On shady rocks in montane forest. *ULU: Mzinga valley, 1400–1600 m (6290/AH); det. B. Afromontane species known from Ruwenzori to S Tanzania.
149. **Brachythecium ramicola** Broth. — On rotten wood in subalpine elfin forest. *ULU: Lukwangule Plateau W 2400 m (6076/BH); det. B. Afroalpine species known from Ruwenzori, Elgon, Muhawura, Mt. Kenya and from Mt. Kilimanjaro at altitude 2500–4550 m.
150. **Brachythecium vellereum** (Mitt.) Jaeg. — Terricolous and on *Senecio* stems in giant Erica heath and in giant groundsel stands. KIL: Mweka Route 2530–2900 m (6718/CG, DC, DE); Umbwe Route, near the IInd Bivouac and behind Barranco Hut, 3330–3950 m (6791/K, 6795/B); det. B. Afroalpine species, EAB IV.
151. **Eurhynchiella decurrens** P. Varde — On soil, rocks and on giant bamboo stems in montane forests. KIL: Umbwe Route 2650–2850 m (6788/CH); Mweka Route 2500–2900 m (6716/N, 6718/BW, BU); *NGU: Mafulumula N 1920 m (6440/H); det. B. Afromontane and afroalpine, known from Ruwenzori to Kilimanjaro, between 1750–4000 m.
152. **Oxyrrhynchium swartzii** (Türn.) Warnst. — On rocks and soil in more open places. *KIL: Upper Kikafu, along irrigation ditches, 1600–1800 m (6346/M); *ULU: Bondwa, Forest Reserve edge above Morningside, 1450 m (6854/Z); det. B. Temperate Eurasia, Madeira, Açores, Algeria. In tropical Africa Mt. Kenya and Mt. Elgon.
153. **Palamocladium sericeum** (Jaeg.) C. Müll. — On all substrates in montane forests. NGO: Oldonyo Oldeani NNW 2700–3000 m (6920/B); KIL: Umbwe Route near IInd Bivouac, 3300 m (6791/E); Mweka Route 2600–2900 m (6718/AF, AS, and others); Marangu

Route 1850–2800 m (6208/F, 6245/AF); *WUS: U.F.R., "Kambo" 1620 m (6374/AF); *NGU: Mafulumula W 1700–1800 m (6441/N, O); Maskat Mission 1500 m (6444/F, O); ULU: Mt. Kifuru E 1580 m (6905/T); Mgeta v. 2250 m (6830/G, AQ and many other records); *RUN: Mt. Rungwe SW 2500–2600 m (6767/C); det. B. East African montane species from Northern Kenya to Cape.

153/A **Palamocladium sericeum** (Jaeg.) Broth. var. **afrostriatum** C. Müll. NGO: near Crater Lodge 2300 m (6196/K); MER: Njeku 2600 m (6520/D); KIL: Shira Route, Wasendo Glade 2600 m (6355/O); ULU: Bondwa NE 1740 m (6578/BB); *KIP: Kitulo Plateau 2650 m (6750/AQ); det. B.

154. **Schimperella atrotheca** (P. Varde) P. Varde — On different substrates in montane forest. KEN: Castle F. St. 1960–2000 m (6603/N); KIL: Marangu — Old Moshi 1700 m (6368/U); *ULU: Falls of Mgeta springs at E edge of Lukwangule Pl. 2350 m (6822/AW); *KIP: Kitulo Plateau 2650 m (6750/AJ); *RUN: Mt. Rungwe SW 2500–2600 m (6767/P); det. B. East African montane species known from Ethiopia to Mt. Kilimanjaro.

155. **Rhynchostegium distans** Besch. — Corticolous in montane forest. *UKA: Mandege F. St. 1500 m (6586/C); det. B. Lemurian element of the East African mountains, from the Ruwanzori to Réunion and Mauritius.

156. **Rhynchostegium horridum** Broth. — On bark, tree fern stem and sometimes on rotten wood in montane forests. *KIL: Umbwe Route 2850–2900 m (6788/J); Nkweseko 1800–1850 m (6359/AA); WUS: U.F.R. "Kambo", 1620 m (6374/AJ); EUS: Amani, Hunga v. 880 m (6514/G); *ULU: Palata NW 1850–2000 m (6852/P); Mwere v. 1480–1550 m (6853/J, 6891/Q, 6893/J); Bondwa N 1450 m (6854/U, AB); det. B. East African montane species known from Uganda to Tanzania.

157. **Rhynchostegium volkensii** (Broth.) Par. — On bark, rotten wood and on bamboo stems in montane forests. *KEN: Kamweti Track 2400–2700 m (6601/AZ); *SPA: Kwizu E 1000 m (6715/S); *WUS: U.F.R., "Kambo" 1620 m (6374/BF); *UKA: SW of Mandege F. St. 1520 m (6869/L); Mt. Ikwamba 1700 (6865/J); *ULU: Midhani 880 m (6881/D); Bondwa N 1400 m (6855/C); SHL: NW of Njombe, 1940 m (6754/B); Mufindi Fishing Camp 1800 m (6324/E); POR: E of Igoma village, 2575 m (6511/F, K); det. B. East African montane, EAB I, IV.

158. **Rhynchostegiella holstii** (Broth.) Broth. — On different substrates in the montane forest belt; only in shady lava cave above the forest line. KIL: Barranco Bivouac 3900 m (6935/B); WUS: U.F.R. near Mazumbai 1620–1880 m (6372/BD, 6374/T); *MER: Ngurdoto crater rim 1800 m (6213/LA); *NGU: Mafulumula W 1700–1800 m (6441/E); *UKA: Mt. Ikwamba NW 1700–1875 m (6865/G); Mt. Mnyera NW 1690 m (6864/C); Mandege F. St. 1500 m (6858/B); ULU: Kinole sawmill 1100 m (6874/K); Lupanga NW 1000–1350 m (6546/E, 6712/C); Morningside 1240 m (6571/D); Chenzema Mission 1700 m (6812/T); *POR: Igali pass near Isangate 1940 m (6748/EB); *KIP: Kitulo Plateau near Igoma village 2650 m (6750/AB); det. B. East African montane species known from East Zaire and from Kenya to Malawi.

## Entodontaceae

159. **Erythrodontium engleri** (Broth.) Par. — Corticolous in mesic montane forest. *UKA: Mt. Mnyere NE 1500 m (6864/J); det. B. Kenya, Tanzania, Malawi.

160. **Erythrodontium rotundifolium** (C. Müll.) Par. — Corticolous in dry evergreen montane forests, in deciduous woodland and on lone trees. *MER: Ngurdoto crater rim, 1800 m (6213/G); *Mt. IPIRI S of Babati, misr effected miombo, 1800 m (6214/B); WUS: U.F.R. Mazumbai, 1500 m (6370/AS); *ULU: Tegetero Mission 975 m (6424/C); *RUN: below Lugumbo village, 1225 m (6768/FA); det. B. East African species known from Ethiopia

to Zimbabwe. According to M. Bizot it is very closely related to, or identical with the preceding species.

161. **Erythrodontium subjulaceum** (C. Müll.) Par. — Corticolous in relatively dry forests, woodlands and on lone trees. *Mt. IPIRI S of Babati, 1800 m (6214/EB; *KIL: Mawingo Estate 1350 m (6350/H); *WUS: Lushoto 1500 m (6204/A); ULU: Mkuyuni 300 m (6021/C); *RUN: Mt. Rungwe SW 1800 m (6777/AE); det. B. Widespread in tropical Africa.
162. **Mesonodon flavescens** (Hook.) Buck. — Syn.: *Campylodontium flavescens* (Hook.) Bosch. et Lac., *C. mauritianum* (C. Müll. ex Besch.) Broth., *C. dusenii* (Broth.) Broth. On bark and branches in submontane rain forest. *ULU: Midhani 880 m (6880/V, 6881/AQ); Tegetero Mission 975 m (6424/UA); *Campylodontium dusenii* (Broth.) C. Müll. probably also belongs here. Det. and annotation by B. Palaeotropic species, widespread in tropical Asia from the Himalayas to Celebes and to the Philippines. In tropical Africa only Mauritius, Malawi and ? Cameroon.
163. **Entodon dregeanus** (Hornsch.) C. Müll. — On bark or on bamboo stem in *Arundinaria alpina* thicket. *KEN: Kamweti Track 2400–2700 m (6601/V, AW); det. B. From the east African mountains to South Africa and to Réunion.
164. **Entodon geminidens** (Besch.) Broth. — On bark or on ground of montane forests and submontane woodlands. *NGU: Mafulumula W 1700–1800 m (6441/P); Maskat Mission 1500 m (6444/H); ULU: Mt. Mindu E 975 m (6841/L); Probably synonymous with the preceding species. Det. and annotations by B. East Africa from Ethiopia to Transvaal, Réunion.
165. **Entodon vulcanicus** Dem. et Leroy — Epiphyte in *Hagenia-Podocarpus-Dombeya-Arundinaria* forest forming the upper forest line. *KIP: Kitulo Pl. 2640–2690 m, E of Igoma village (6740/M, BA); det. B. East African montane species: Aberdare, Mt. Mikéno, Ngorongoro Crater, Rungwe volcano, between 2200–2800 m.
166. [1]**Levierella perserrata** P. Varde et Leroy — Syn. nov.: *L. abyssinica* Broth. nom. nud., *L. fabroniacea* C. Müll. var. *abyssinica* Dix. On wet rocks. *ULU: S of Mgeta village, 1340 m (6392/F); *Z: Under Kundalila Falls SE of Kanona, 1430 m (6623/D); det. B. Ethiopia, E Zaire, Uganda.

## Plagiotheciaceae

167. **Stereophyllum nitens** Mitt. — On different substrates of lowland and submontane forests. *UKA: along Msowero stream 600 m (6745/B); ULU: Kimboza F. Res. near Mkuyuni 350–450 m (6800/T); Kitulanghalo Forest Reserve NE of Morogoro, 500–550 m (6559/D, E); det. B. Widespread in tropical Africa.
168. **Stereophyllum radiculosum** (Hook.) Mitt. — On different substrates in all kinds of forests up to 2000 m alt. *K: Forest Res. NE of Nairobi, 1800 m (6607/B); MER: Ngurdoto crater rim 1800 m (6213/N, LB); *KIL: Kikafu gorge near Kyere 1500 m (6347/J); *SPA: Kwizu E 875 m (6716/P); *NGU: Mafulumula N 1920 m (6440/F); Maskat Mission 1500 m (6444/G, J); ULU: Morogoro river v. near Bahati Camp, 600 m (6561/G); Kigurunyembe 700 m (6723/G, N); Midhani 850–900 m (6882/G); *USG: Gologolo Mts. below Sanje Falls, 300 m (6144/AC); *Z: Victoria Falls, Palm Grove 800 m and Knife Edge at 870 m (6614/S, 6613/J); det. B. Probably much more widespread in tropical Africa, than it is known at present: Cameroon, Guinea, Gabon, in East Africa only from the Ulugurus and from Arusha Nat. Park. If its identity with *S. indicum* (Bél.) Mitt. will be proved,

[1] According to Buck (1980: 128) *Levierella* belongs to the family of *Fabroniaceae*.

can characterized, as a pantropical species, being common in tropical and subtropical America too.

169. **Plagiothecium mildbraedii** Broth. in Mildbr., Wiss. Ergebn. Deutsch. Zentr. Afr. Exp. 2: 169 (1910). Syn. nov.: *Plagiothecium alluaudii* Thér., Bull. Mus. Hist. Nat. Paris 30: 245 (1924). — On bark and on ground of montane forests. KIL: Mweka Route 2750 m (6718/CT); Marangu Route 220 m (6365/AB); Rectification: in EAB I under No. 403, *P. nitens* Dix. is also *P. mildbraedii* from the Ulugurus, Bondwa top. Det. and annotations by B. East African montane species distributed in the upper forest belt above 2000 m ascending as high as 4140 m in Ruwenzori Mts.

170. **Plagiothecium nitens** Dix. — On bark in montane forest. ULU: Kinazi NW 1400–1650 m (6289/AO); det. B. EAB I.

### Sematophyllaceae

171. **Gammiella merrillii** (Broth.) Tix. Syn.: *Clastrobryella foliicola* P. Varde — Ramicolous and epiphyllous in montane forests. ULU: Bondwa NE 1640 m (6844/D); det. B. Palaeotropic species: Zaire, Tanzania: Nguru and Uluguru Mts., Madagascar, from India to Philippines and to Japan.

172. **Heterophyllium flexile** (Ren. et Card.) Thér. et P. Varde — On different substrates in montane forests. *KIL: Nkweseko, 1700–1800 m (6359/AD); *NGU: Maskat Mission 1500 m (6444/N); *UKA: Mnyera ridge S 2000 m (6742/AC); ULU: Kinazi N 1950 m (6838/H); Mwere v. 1440 m (6895/M); Bondwa, all slopes 1600–2130 m (6052/CN, 6228/D 6578/C); *SHL: Mufindi, Kilima Estate 1725 *J* (6780/L); *Z: Mukowonshi Mts., "mist, forest" 1800–1840 m (6629/V); det. B. According to the senior author it seems to be a form of *Rhacopilopsis trinitensis* (C. Müll.) Britt. East African montane species widespread from the Ruwenzori to Mozambique and to Madagascar.

173. **Heterophyllium kilimandscharicum** (Broth. et P. Varde) Thér. et P. Varde, Syn.: *Acanthocladiella kilimandscharica* Broth. et P. Varde — Rupicolous in submontane rain forests. *ULU: Msanga Falls 1150 m (6110/X); above Simbini village, 1400–1500 m (6418/AG); det. B. Known only from the type locality: Kilimanjaro Mts., Old Moshi, 1960 m alt.

174. **Wijkia cuynetii** (Biz.) W. Sch.-Mot. — Epiphyte and on shady rocks in montane forests. *KEN: Castle F. St. 1960–2020 m (6603/P, 6602/H); *KIL: Nkweseko, 1700–1800 m (6359/AB); ULU: Bunduki, Kikododo, 1600–1750 m (6463/N); Midhani 880 m (6880/R); Tumbako S, SE 1390–1530 m (6876/AB, 6877/A); Lupanga NW 1600–1800 m (6548/K); det. B. All records published in EAB I. No. 407 under *Acanthocladium trichocoleoides* (C. Müll.) Broth. also belong here. Afromontane species known from Cameroon Mts. and from the East African highlands.

175. **Wijkia rutenbergii** (C. Müll.) Crum — Corticolous, in submontane rain forests. *EUS: Amani 860 m (6105/AM); NGU: Kwamanga — Mhonda Mission 700–1100 m (6396/H); det. B. New for continental Africa, previously known only from Madagascar.

176. **Wijkia trichocolea** (C. Müll.) Crum — On bark and on shady rocks in montane forests. KIL: Marangu Route 1800–1900 m (6211/F); WUS: Mazumbai U.F.R. 1750–1880 m (6372/AR); *UKA: N of Mandege F. St. 1540 m (6737/M, N, O); Mnyera N 1900 m (6870/M); det. B. Afromontane species known in Gabon and from Ethiopia to Zimbabwe: Inyanga Mts.

177. **Wijkia trichocoleoides** (C. Müll.) Crum — On ground of montane forest. *RUN: Mt. Rungwe SW 2450 m (6766/J); det. B. Previously known from São-Tomé, Cameroon and from Mt. Kenya (other erroneous data see above, by No. 174).

178. **Meiothecium usambaricum** (Broth.) Broth. — Epiphyte in submontane rain forest and

in mist effected miombo woodland. *ULU: Midhani E 880 m (6881/AT); Mt. Mindu E 850–1150 m (6841/J); det. B. Previously known only from the Usambara Mts.

179. **Warburgiella leptorrhyncha** (Jaeg.) Broth. — Corticolous in montane forest. *ULU: Palata W 1520–1650 m (6849/F, J); Bondwa NE 1580 m (6844/B); det. B. Known from the East African highlands and from Madagascar and the Mascarenes.

180. **Sematophyllum caespitosum** (Hedw.) Mitt. — All kinds of substrates in submontane and montane forests up to 2350 m alt. *KIL: Kinukamari Falls near Marangu, 1500 m (6237/K); Ghona v. near Mahom, 1400 m (6366/C); *EUS: Amani, on concrete dike, 850 m (6095/B); *UKA: Mnyera WNW 1800–1950 m (6743/G); *ULU: Midhani 880 m (6880/AH, 6881/AH); Kigurunyembe v. 1000 m (6046/M); Morningside 1250 m (6571/F, 6575/D, 6899/A); Bondwa N, NE 1450–1700 m (6430/C, 6553/E, 6781/D, 6848/E); Tegetero Mission 975 m (6424/D); Mgeta valley 1600–2350 m (6829/W, 6822/AA, 6911/B); *RUN: Rungwe village 1500–1800 m (6758/D, 6777/AD); det. B. Pantropical species. Judging from the amount of the above records, it must be much more widespread in Africa, than previously known.

181. **Sematophyllum dregei** (C. Müll.) Magill. — Syn.: *Rhaphidorrhynchium dregei* (C. Müll.) Broth. *Rhaphidorrhynchium ruwenzorense* Dix. et Thér. might also be conspecific with the above (annotation by B). On bark and on bamboo stem in montane forests. *NGU: Mafulumula coll above Mnembule village, 1650–1800 m (6438/Z); *ULU: Mgeta v. 2250 m (6830/W); *RUN: Mt. Rungwe SW 2500–2600 m (6767/N); det. B. Known distribution: From Cape to Zambezi River (and to Ruwenzori Mts.?).

182. **Sematophyllum elgonense** (Dix.) Broth. — Ramicolous in giant Erica heath. KIL: Umbwe Route, near Ist Bivouac, 2800–2900 m (6929/GA); det. B. Afroalpine species known from localities near to forest line at alt. 2400–3800 m in Ruwenzori, Elgon, Aberdare, Kilimanjaro and Southern Highlands of Tanzania.

183. **Sematophyllum fulvifolium** Mitt. — Epiphyte in montane forests. *ULU: Tumbako S 1500 m (6877/O); Lupanga SW 1700–1900 m (6285/BX); *UKA: Mnyera ridge 2100 m (6871/PA); det. B. New for East Africa, previously known from the Rodriguez Islands, Central African Republic and from Gabon.

184. **Sematophyllum obtusifolium** (Ren. et Card.) Broth. — On irrigated rocks and on sprayed bark in fringing forests. *NGU: Maskat Mission 1500 m (6444/J); *ULU: above Kisimbi Falls, 800 m (6498/D); *SHL: Mufindi, along stream below the Fishing Camp, 1720 m (6323/R); *RUN: below Lugumbo village, 1225 m (6768/J); *Z: above Kundalila Falls SE of Kanona, 1490 m (6626/B); det. B. Previously known from Madagascar, Gabon and from the Kilimanjaro Mts.

185. **Sematophyllum sinuosulum** (Besch.) Broth. — Ramicolous in montane forest. ULU: Mwere v. 1500 m (6531/D); det. B. EAB I.

186. **Sematophyllum subbrachytheciiforme** P. Varde — On different substrates from lowland to montane forests. KEN: Kamweti Track 2400–2700 m (6601/W); KIL: Umbwe Route 2200–2600 m (6786/GA); *MER: Ngurdoto crater rim 1800 m (6213/H); *SPA: Mt. Kwizu E 875–940 m (6716/O, Q); *NGU: Maskat Mission 1500 m (6444/M); *UKA: Mnyera ridge 2100 m (6740/AA, AP); *ULU: Kimboza F. Res. 400 m (6800/P); Mt. Mindu 1200 m (6843/AG); Bondwa, all slopes and top 1450–2100 m (6528/B, 6844/K, 6847/N); Kinazi N 1950 m (6838/H); Mgeta v. 2250 m (6830/AL); *RUN: E of Rungwe village 1500 m (6758/F); Mt. Rungwe E 2500–2800 m (6504/O, Q, 6507/M); *POR: small collapsed crater S of Isongole 1960 m (6757/D); *Z: below Kundalila Falls SE of Kanona 1425 m (6624/F); Mt. Mulilidwa SE of Shiwa Ngandu 1500 m (6627/M); det. B. An East African species with much wider range both altitudinally and geographically, than one could anticipate from the previous records: Ruwenzori 3150 m, Kenia 2500–3000 m, Kilimanjaro 3800 m.

187. **Acroporium megasporum** (Duby) Jaeg. — Epiphyte and lignicolous in submontane and in montane forests. ULU: Tumbako S, SE 1350–1500 m (6877/B, 6876/R); Mt. Kifuru 1750–1800 m (6913/D, F); Palata NW 1850–1900 m (6852/L); det. B. Tropical African species known in scattered localities from Cameroon to Réunion.
188. **Trichosteleum humbertii** P. Varde — On different substrates in montane forests. KIL: Umbwe Route 2650–2850 m (6787/A); *UKA: Mnyera ridge 2100 m (6871/PB); ULU: Lupanga WNW 1900–2050 m (6550/OB); Palata NW 1850–1900 m (6852/M); Bondwa near the top above 2000 m (6404/AG, 6888/K); this species is probably a *Warburgiella.* Det. and annotation by B. EAB I.
189. **Trichosteleum jonesii** Bizot ex Pócs — On shady rock face in submontane rain forest. *ULU: Mwere v. 1440 m (6895/C); det. B. Previously known only from the type locality: Mufindi in the Southern Highlands of Tanzania.
190. **Trichosteleum mamillipes** Broth. — Usually on rotten wood, associed with *Hookeriaceae,* in submontane and in montane forests. *KIL: Umbwe Route 1900–2200 m (6191/AJ p.p.); ULU: Lupanga WNW 1900–2050 m (6550/OA, R); Mwere v. 1400–1600 m (6158/AH, 6160/G, 6533/E, 6893/L, S); Palata NW 1700–1850 m (6851/L); Midhani 880 m (6880/AD); Lupanga — Kinazi ridge 1800–1900 m (6836/AH); *NGU: Mafulumula coll above Mnembule village, 1650—1800 m (6438)/X); det. B. Tropical African species known from Liberia to Tanzania.
191. **Macrohymenium acicodon** (Mont.) Dozy et Molk. — Ramicolous in montane forest. *UKA Mnyera ridge, 2100 m (6871/M); det. B. Lemurian species known from East Africa only from the old crystalline massifs, as Taita Hills in Kenya and the Uluguru Mts.

## Hypnaceae

192. **Bryosedgwickia densa** (Hook.) Biz. et P. Varde, Syn.: *Erythrodontium densum* (Hook.) Par. *Leskea densa* Hook. — On relatively dry rock cliffs in *Brachystegia woodland* (miombo). *Z: Great East Road between Undaunda and Rufunza, 135 km E of Lusaka, 1300 m (coll. J. KORNAŚ 10/B); det. B. Previously known from Central America and from West Africa: Guinea, Central African Republic, from Southeast Africa only Zambia: Mbala.
193. **Hypnum aduncoides** (Brid.) C. Müll. — Terricolous in montane forest. *KIL: Mweka Route 2600–2800 m (6718/AQ); Marangu Route 2800 m (6943/F); det. B. Palaeotropic species, in Africa known only from Mt. Kenya, Victoria Falls, from the Usambara and Uluguru Mts. and from the Mascarene Islands.
194. **Hypnum cupressiforme** Hedw. — On different substrates in montane forests and in afroalpine communities. KEN: Kamweti Track 2000–2700 m (6601/S, 6602/K); ABE: Gikururu v. 1 ml W of Kiandogoro Gate 3000 m, on giant Senecio stem (coll. Mabberley 325, 327/C); NGO: Oldeani NNE 2700–3000 m (6920/G); MER: E crater edge 2600 m (6341/AT); KIL: Shira Route 2600–3700 m (6355/H, 6925/O); Umbwe Route 2200–4000 m (6786/GB, 6788/U, 6798/C, 6929/GB, 6933/T, JA); Mweka Route 2640 m (6718/CE); *UKA: Mnyera ridge 2100 m (6871/AR); ULU: Lupanga — Kinazi 1800–1900 m (6836/AM); Bondwa top 2130 m (6052/AY); *KIP: Kitulo Pl. 2650 m (6750/L); det. B. Cosmopolite, altimontane in East Africa, occurring only above 2000 m alt.
195. **Breidleria africana** P. Varde — Terricolous in montane forest. *KIL: Umbwe Route 1900–2100 m (6352/AE); det. B. Previously known only from the Ruwenzori Mts. and from Muhawura at alt. 3750–4100 m.
196. **Ectropothecium duemmeri** Dix. — On roots, in montane forest. *ULU: Bondwa NE 1700–2000 m (6888/J); det. B. Known only from the type locality in Uganda.
197. **Ectropothecium regulare** (Brid.) Jaeg. — Mostly on soil or on shady rocks, sometimes on Cyathea stem in dense forests. *UKA: near the falls below Mandege F. St. 1200 m

(6744/C); ULU: Kigurunyembe 700 m (6723/S); Palata ridge 1700–1850 m (6851/D); Mgeta v. above Hululu Falls 1600 m (6911/D); Bunduki, Kikododo 1900 m (6464/BF); *SHL: behind Kilima Tea Factory, 1725 m (6780/O); *RUN: Mt. Rungwe SW, Jona gorge 1700–1800 m (6778/E); det. B. Widespread tropical African species, EAB I, II, IV.

198. **Ectropothecium revolutum** Broth. — On bark, in submontane forests. ULU: above Kisimbi Falls, 850 m (6499/D); Tumbako SE 1050 m (6167/AC); det. B. Seems to be a lowland forest element known from Cameroon, East Usambara and from the Uluguru Mts.

199. **Ectropothedium sericeum** P. Varde — On bark and wood in submontane forests. *ULU: Kinole, Midhani 860 m (6881/AH); Mwere v. 1500 m (6893/K); det. B. Previously known only from Mt. Kilimanjaro at 4050 m altitude. According to P. Varde (1955: 195) it is related to the preceding species. The extreme altitudinal records suggest the necessity of revision of the above two species. Annotation by P.

200. **Isopterygium sericifolium** Dix. — On overhanging lava rocks in giant Erica heath. *KIL: Umbwe Route, 2850–2900 m (6788/H, AE); det. B. Afroalpine, known from Ruwenzori, Kenia and Uluguru Mts.

201. **Vesicularia galerulata** (Dub.) Broth. — On bark and rocks in submontane and montane rain forest. *WUS: Mazumbai U.F.R. 1600–1750 m (6371/AD); *UKA: Mandege F. St. 1500 m (6586/D); *ULU: Mzuazi v. near Midhani, 850 m (6882/J); above Simbini village, 1400–1500 m (6418/AJ); Bondwa N 1450 m (6430/H); Mgeta v. 1600–1640 m (6912/Y); det. B. EAB I.

202. **Taxiphyllum gabonense** Broth. et P. Varde var. **plagiothecioides** P. Varde — On rocks in submontane forest. *SPA: Kwizu E 1000 m (6716/R); det. B. EAB I.

203. **Mittenothamnium ctenidioides** (Dix.) Schelpe — On Cyathea stem in montane rain forest. *ULU: Mwere v. 1570 m (6891/N); det. B. Previously known only from Cape, new for East Africa.

204. **Mittenothamnium cygnicollum** (Dix.) Wijk. et Marg. — On soil, bark, rotten wood and sometimes on *Cyathea* stem in montane forests. *KIL: Marangu — Old Moshi 1750 m (6368/AG); *WUS: Mazumbai U.F.R. 1500 m (6370/AO); *UKA: Mandege F. St. 1520 m (6869/P); Mt. Kifigo SE 1600–1760 m (6591/C); ULU: Kinole sawmill 1050 m (6264/E); Mwere v. 1550 m (6893/A); Bunduki F.R., Kifuru E 1580 m (6905/H); Lupanga E, WNW 1750–2050 m (6550/N, 6468/G); Bondwa N, NE 1800–2050 m (6230/Q, 6845/G); det. B. Widespread montane species from North Kenya to Cape.

205. **Mittenothamnium microthamnioides** (Geh.) Wijk et Marg. — On rotten wood in montane forest. *Z: Mukowonshi Mts. 45 km SE of Mpika, 1800–1850 m (6629/R); det. B. Known from Elgon and from Ruwenzori Mts., from Mozambique and from Madagascar.

206. **Mittenothamnium patens** (Hampe) Card. — On bark and soil in submontane and in montane forests. *ULU: Bunduki near Hululu Falls, 1480 m (6901/D); Bondwa NE 1740–2020 m (6403/AK, 6578/AD); det. B. Known from Transvaal and from the East Usambara Mts.

207. **Mittenothamnium pseudoreptans** (C. Müll.) Card. — On bark in elfin woodland. *UKA: Mamiwa E 2200 m (coll. Mabberley 1396); det. B. Previously known from Zimbabwe: Inyanga Mts., Transvaal, Natal and from Cape.

208. **Rhacopilopsis trinitensis** (C. Müll.) Britt. et Dix. — On bark and on rotten wood in submontane and in montane forests. *KIL: Umbwe Route 2390 m (6786/B); *EUS: Amani 900 m (6086/AY); *NGU: Duale v. between Mhona and Kombola villages, 600–900 m (6435/F); W of Mhonda Mission 800–1000 m (6400/L); W of Kwamanga village 1100–1400 m (6397/AG); *UKA: Mnyera W 1800–1950 m (6743/F); *ULU: Mkungwe F. Res. 800–1100 m (6218/P); Nguru ya Ndege top 1100–1300 m (6459/Q); Bunduki Fishing Camp 1275 m (6907/E, G); Tumbako SE 1390–1500 m (6877/Q, 6876/S); Simbini 1400–1500 m (6418/AK); Hululu Falls 1450–1500 m (6900/G); Kifuru S 1980–2010 m

(6915/F); Bondwa top 2120 m (6889/V, BD, BU); *RUN: SW 2450 m (6766/H); *Z: Mukowonshi Mts. 45 km NNE of Mpika 1840 m (6629/T); det. B. Tropical America and Africa. Seems to be more widespread, than the previous data suggest — cf. EAB I.

### Polytrichaceae

209. **Pogonatum aloides** (Hedw.) P. Beauv. — On roadside banks in the montane forest belt. *ULU: Bondwa N 2100 m (6848/B); *SHL: behind Kilima Tea Factory, 1725 m (6780/AA); det. B. Boreal temperate species not rare in African mountains from Kenya to Malawi.
210. **Pogonatum capense** (Hpe.) Jaeg. — On roadside bank in montane forest. *ULU: Bondwa N 1700 m (6553/F); det. B. South African species known from the Victoria Falls to Cape and from Madagascar.
211. **Pogonatum oligodus** (C. Müll.) Mitt. Syn.: *P. simense* (B.S.G.) Jaeg. — On soil of rocky grassland above the forest line. *KIP: Kitulo Plateau, 2700 m (6752/J); det. B. South America: Columbia, Ecuador, Chile; Tropical Africa: Cameroon, Ethiopia, Mt. Elgon, Kilimanjaro, South Tanzanian highlands, Transvaal, Natal.
212. **Pogonatum theriotii** Dem. et Leroy — On roadcut surface in montane forest. *UKA: Mandege Forest Station, 1530 m (6736/B); det. B. Previously known only from the type locality: Zaire, Kivu, 1800 m.
213. **Pogonatum usambaricum** (Broth.) Par. Ind. Bryol. 990 (1898). Basionym: *Polytrichum usambaricum* Broth. Bot. Jahrb. 20: 194 (1894). Syn. nov.: *Pogonatum holstii* (Broth.) Par. Ind. Bryol. 981 (1898). Basionym: *Polytrichum holstii* Broth. Bot. Jahrb. 20: 194 1894). — On the ground and rocks of submontane and montane forests, subalpine giant Erica heath up to 3000 m alt. *ABE: Aberdare Nat. P., 3000 m (coll. H. Balslev 651); *KEN: Castle F. St. 2000 m (6603/M); WUS: Mazumbai U.F.R. 1500 m (6370/AT); *UKA: 1 km SW of Mandege F. St. 1530 m (6868/A); ULU: Manga E 1200 m (6225/D); Bondwa N 2100 m (6848/A); Lupanga crest SW 2050 m (6551/E); Mgeta v. 2215 m (6829/K); det. B. East African montane species.
214. **Polytrichum commune** Hedw. — On the soil in afroalpine communities near the forest line. KIL: Maungu crater floor above Mandara Hut, 2900 m (6941/A); ABE: Gikururu v. 1.5 km W of Kiandagoro Gate, 2950 m (coll. Mabberley 334); det. B. Cosmopolite, montane in tropical Africa, usually in habitats above 2000 m.
215. **Polytrichum keniae** Dix. — Terricolous in subalpine *Erica arborea* giant heath. KIL: Umbwe Route 2850–2900 m (6788/AS); det. B. Afroalpine species known from Cameroon, Elgon, Ruwenzoni, Kenia, Muhawura, Meru and Kilimanjaro Mts. above 3000 m altitude.
216. **Polytrichum subformosum** Besch. — On soil and rocks of montane forests and subalpine Philippia heath. *KEN: Kamweti Track 2400–2700 m (6601/AB); *KIL: Mweka Base Hut 3000 m (6720/A); ULU: Lukwangule Pl. 2450 m (6815/A); SHL: behind Kilima Tea Factory, 1725 m (6780/AB); det. B. We consider this species a synonym of *Polytrichum commune* Hedw. var. *perigoniale* (Michx.) Kindb. also widespread in the East African mountains (cf. Bizot et al. 1979: 164) but to make a final decision, it seems to be necessary to compare the types of concerned taxa.
217. **Polytrichum piliferum** Hedw. — On the ground of afroalpine communities. KIL: Umbwe Route 3700–3950 m (6797/P, BB); det. B. An almost cosmopolite (bipolar temperate) species restricted to the altimontane habitats in tropical Africa betw. 3400–4400 m.

## On the geographical distribution of species enumerated in East African Bryophytes III and V

The junior author tries to analyse the distributional pattern of the enumerated species, especially in groups, where many additional data were recorded compared to previous publications.

### 1. Afroalpine elements

Bizot and Pócs (1974: 386) supplied a preliminary list based on the species enumerated in EAB I. In our EAB III and EAB V further records were published, mostly on species, which where known from other Afroalpine localities, as from Ruwenzori, Elgon, the Birunga volcanoes and from Mt. Kenya, and recently became known from Mt. Kilimanjaro. Kilimanjaro is regarded to have, along Mt. Meru, the driest climate among the high mountains of Africa. This is the truth in general and fits especially to the usual access of the mountains, the Marangu Route and to the north western approach, accessible by four wheel driven cars, the Shira Route. On the other hand, the Mweka Route, and especially the Umbwe Route goes through a much higher rainfall area comparable with places on the slopes of Ruwenzori and of the Birunga volcanoes. Until recent days, these sections of the mountains were very under-collected and many bryophytes recorded till now from other mountains with higher precipitation, became known from these parts, as: *Kurzia irregularis*, *Leptoscyphus hedbergii*, *Aniso-*
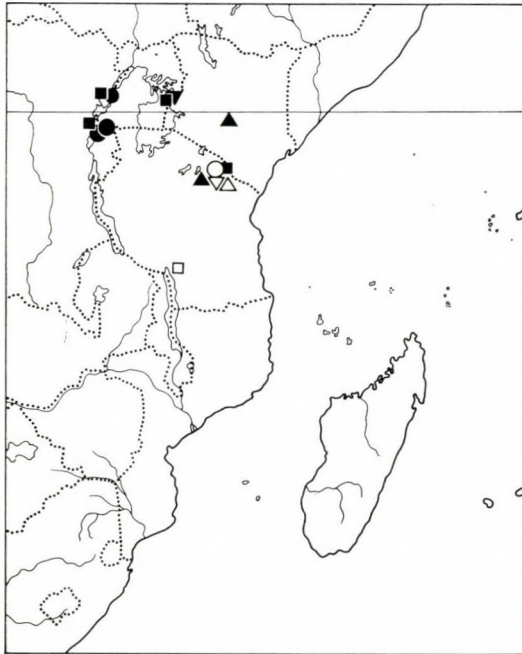
*Fig. 23.* Distribution of afroalpine elements. Circle: *Kurzia irregularis*, upside triangle: African range of *Leptodontium luteum*, down turned triangle: *Mielichoferia elgonensis*, square: *Funaria volkensii*. Here and on the following maps black dots mean the previously known, empty dots represent the new records

*thecium ugandae, Atractylocarpus alticaulis, Rhabdoweisia africana, R. lineata, Bryoerythrophyllum alpigenum, B. rubrum, Mielichoferia cratericola, M. elgonensis, Bartramia microcarpa, Philonotis platyneura, Leptodontiopsis fragilifolia, Brachythecium ramicola, Sematophyllum elgonense, Breidleria africana, Isopterygium sericifolium,* and others. Several species previously known from typical afroalpine habitats, were discovered in mountain areas between 2000 and 3000 m altitudes, from relic localities, as *Anisothecium ugandae* (Uluguru, 2215 m); *Funaria volkensii* (Kitulo Pl. 2700 m); *Pohlia chrysoblasta* (Rungwe 1960 m); *Rhynchostegiella decurrens* (Nguru 1920 m); finally some rare species only once collected before, were recollected in the same or in other mountains, like *Colura berghenii, Fissidens spinosolimbatus,* or *Breutelia humbertii.* Since the publication of EAB I the status and range of an afroalpine species, previously known as *Campylopus procerus,* has been cleared (FRAHM 1980: 216, with distribution map). According to FRAHM (l.c.) the species is synonymous with the South American *C. jamesonii* (Hook.) Jaeg., which lives on the paramos and subparamos of the Cordilleras among very similar conditions to its afroalpine and afro-subalpine habitats.

The following boreal temperate elements not mentioned in EAB I (BIZOT and PÓCS 1974: 386) live usually also in afroalpine habitats: *Philonotis fontana, Cratoneurum filicinum, Oxyrrhinchium swartzii* and *Pogonatum aloides,* while *Amphidium cyathicarpum* is a southern temperate species.
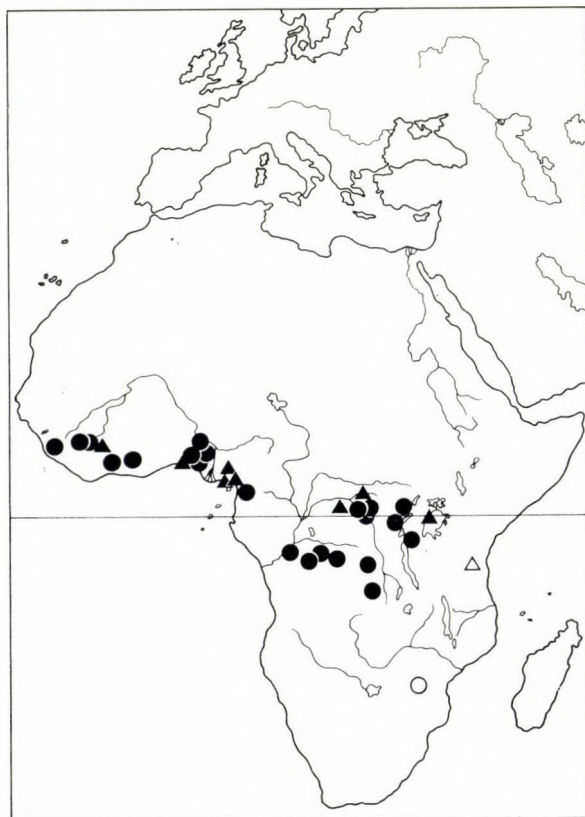
*Fig. 24.* Lowland tropical forest elements. Circle: *Leptolejeunea astroidea,* triangle: *Cololejeunea cuneifolia*

### 2. The "Mediterranean" group

An interesting group of species, which typically in the South European and North African Mediterranean region is distributed, sporadically occur not only in the region of South Africa characterized by similar climatic conditions, but also in many dry montane localities of East Africa, as *Fossombronia husnotii*, *Exormotheca pustulosa*, *Fissidens algarvicus*, *Funaria calcarea* var. *convexa*, and others, mentioned by Bizot and Pócs (1974: 393) and by Pócs (1976: 103).

### 3. South African elements

with disjunct occurrence in East African mountains: *Odontoschisma africanum*, *Mannia capensis*, *Fissidens borgenii* var. *obtusifolius*, *F. simii*, *F. breutelii*, *F. hoegii*, *F. mac-owanianus*, *Bartramia hampeana*, *Schlotheimia percuspidatum*, *Pseudoleskea leskeoides*, *Rhaphidorrhynchium dregei* and *Mittenothamnium ctenidioides*. They occur usually in the montane forest belt between 1000 and 2500 m in East Africa.

### 4. Lowland forest elements

As is discussed in EAB I (Bizot and Pócs 1974: 391), they are widespread in West and Central Africa, in the Guinea-Congo basins and have very disjunct area in East Africa, where lowland and submontane forests are restricted to small, scattered patches of the coast and the foothills and rainy slopes of the old cristalline massifs of Kenya, Tanzania, Malawi, Zimbabwe
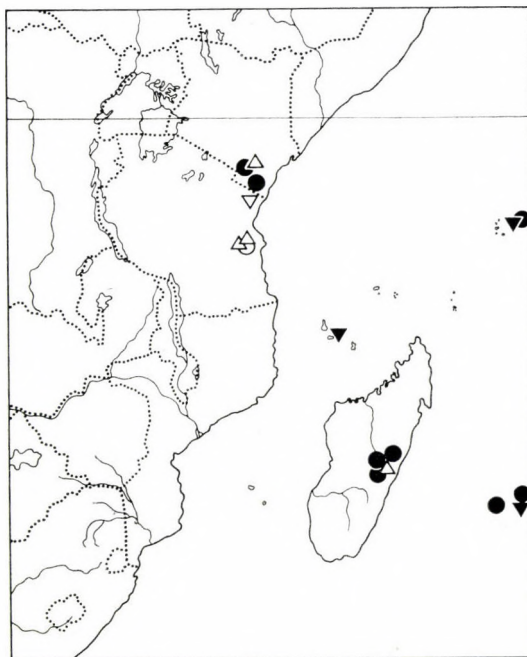
*Fig. 25.* Distribution of Lemurian elements. Circle: *Drepanolejeunea madagascariensis*, upside triangle: *Diplasiolejeunea zakiae*, down turned triangle: *Leucophanes mayottense*
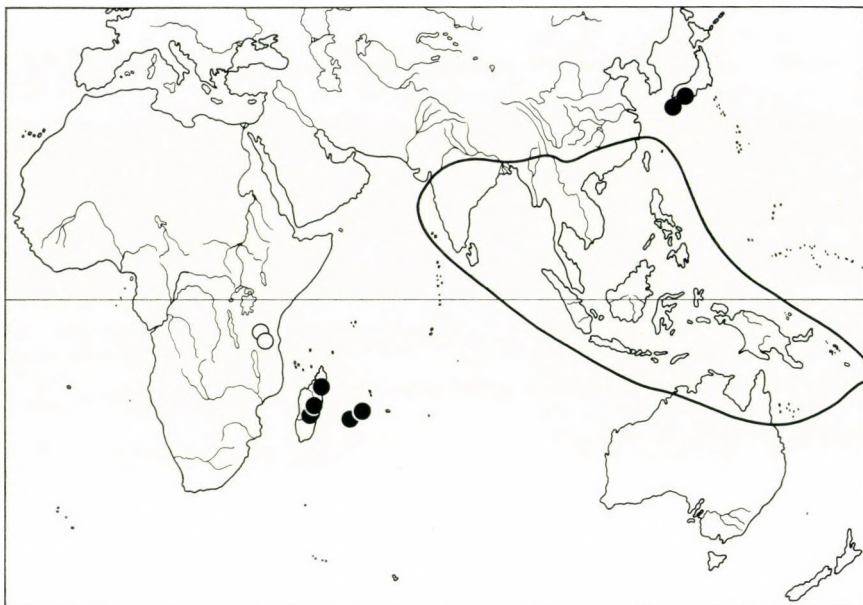
*Fig. 26.* The distribution of a palaeotropic species: *Homaliodendron exiguum*

and Moçambique, where occur between altitudes of 100 and 1500 m: *Cololejeunea cuneifolia, Caudalejeunea dusenii, Leptolejeunea astroidea, Fissidens calabariae, F. diaphanodonta, F. parkii, F. pierrotii, F. rivicola, F. smilioides, F. vogelianus, Pinnatella oblongifrondea, Chaetomitrium dusenii, Callicostella perpapillata, Anacamptodon africanus, Schwetschkea schweinfurthii* and many others.

## 5. Lemurian elements

Since the first account given on the Madagascar-Mascarenian elements occurring in East Africa (Pócs 1975) their number increased, even by our two papers with almost 50 species: *Jamesoniella purpurascens, Schistochila sphagnoides, Paraschistochila englerana, Frullania bullata, F. usambarana* var. *reducta, Cololejeunea cuneata, Drepanolejeunea madagascariensis, D. cambouena, D. trematodes, Diplasiolejeunea cornuta, D. zakiae, Fissidens hymenodon, F. lacouturei, F. reflexus, F. planifrons, F. ventroalaris, Trematodon mayottensis, Aongstromea vulcanica, Campylopus flageyi, Holomitrium borbonicum* var. *hamatum, Leucoloma grimmioides, L. perrottii, Brachymenium pulchrum, Orthodontium loreifolium, Leucophanes mayottense, L. renauldii, L. seychellarum, Bartramia gigantea, Breutelia borbonica, B. perrieri, B. gnaphalea, Macromitrium rufescens, M. subpungens, M. urceolatum, Schlotheimia angulosa, Sch. excorrugata, Sch. robusta, Papillaria borchgrevinkii, Cyclodictyon aubertii, Lopidium hemiloma, Wijkia rutenbergii, Warburgiella leptorrhyncha*; also in South Africa: *Lejeunea villaumei, Macromitrium tristratosum, Calyptrochaeta asplenioides* and *Pogonatum capense* belong here. As it was already underlined (Pócs and Bizot 1974: 393, Pócs 1975: 126, 1981: 303–305), these Lemurian elements distributed before the dissection of Gondwanaland, and occur mainly (41 out of 46 !) in the old crystalline mountains of mainland Africa, only 5 of them live on the younger volcanoes !

**6. Palaeotropic species**

Since the last account on this group of species, which are distributed both in tropical Africa and Asia (Pócs 1975), several publications reported either new occurrence of species, previously known, as Asian, in Africa, or new synonymy, which proved that African and Asian species are identical (Grolle 1977, 1981), Tixier (1975, 1977), Jones (1979, 1980), Townsend (1978), and others. EAB III and V include the following additional palaeotropic species: *Cheilolejeunea decursiva*, *Cololejeunea bolombensis*, *C. filicaulis*, *C. hyalino-marginata* (earlier syn. of *C. leloutrei*), *Tortula schmidii* (earlier syn. of *T. hildebrandtii* or *T. erubescens*), *Macromitrium fasciculare*, *Homaliodendron exiguum* (the former records being erroneous), and *Gammiella merrillii* (syn. of *Clastrobryella foliicola*).

**7. Neotropic species**

*Zygodon pungens* is first recorded from Africa. *Rhacopilopsis trinitensis* and *Stereophyllum radiculosum* seem to be much more widespread. *Campylopus jamesonii* and *Leptodontium luteum* are the common elements of the altimontane vegetation of South American Cordilleras and East African high volcanoes.
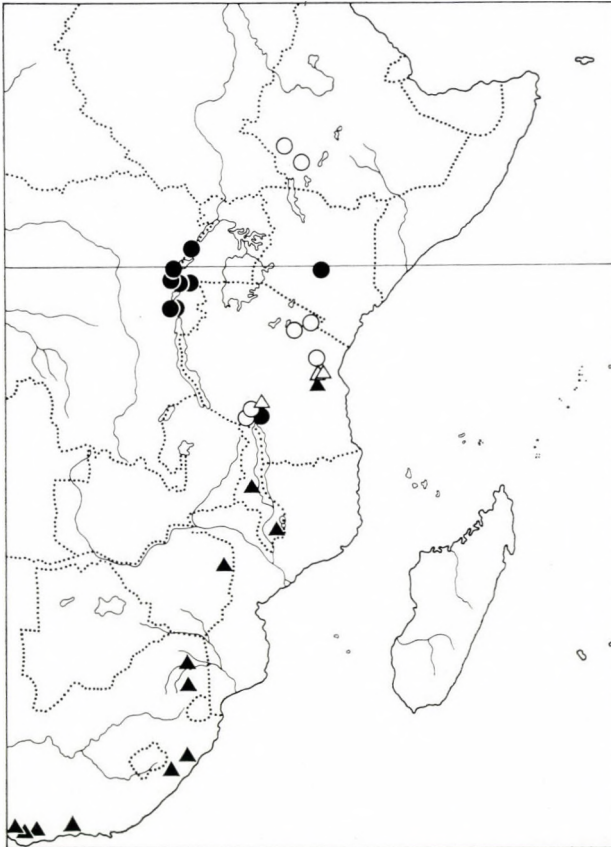
*Fig. 27*. The distribution of an afromontane element in East Africa: *Hylocomiopsis cylindricarpa*, based on the map of De Sloover (1976: 384), with new records added (circle), and of a Southeast African species: *Schlotheimia percuspidata* (triangle)
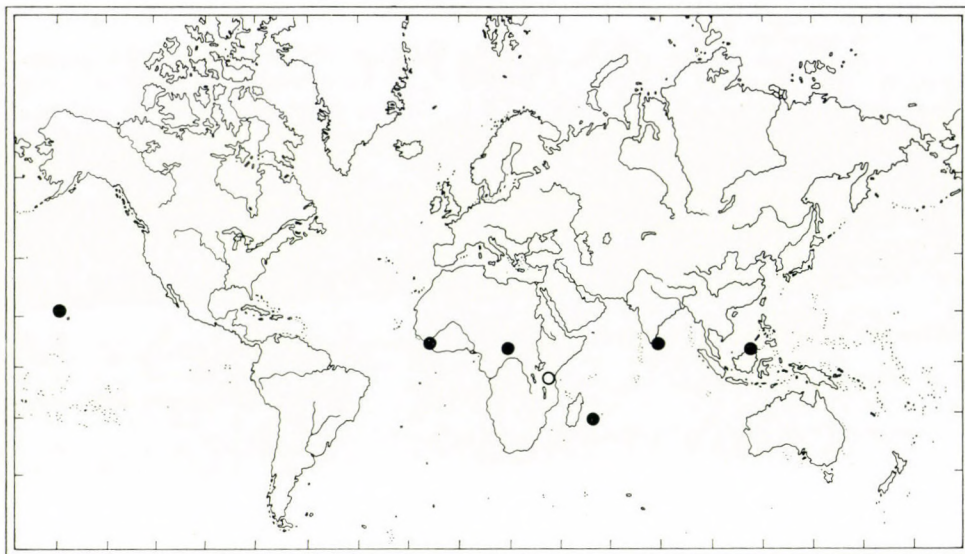
*Fig. 28.* The distribution of a palaeotropic species: *Cheilolejeunea decursiva*

A great part of the enumerated species belongs to the afromontane or east African montane distribution pattern. We do not go in details about their range, because full information will be given by a Checklist of the Mosses of South and East Tropical Africa (under preparation by G. Kis).

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# STUDIES IN RONDELETIEAE (RUBIACEAE) III. THE GENERA ROGIERA AND ARACHNOTHRYX

A. Borhidi

ECOLOGICAL AND BOTANICAL INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

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Based on a comparative study of the North American species of the genus *Rondeletia*, author found essential generic differences between the Antillean and Central American species. Revalidates the genera *Rogiera* Planch. and *Arachnothryx* Planch. with amplified descriptions and respective combinations.

As it was pointed out (Borhidi and Fernandez 1982: 309) the original concept of *Rondeletia* L. has been largely widened by De Candolle (Prodr. 4: 406, 1830) and Bentham (Pl. Hartw. 1841). Planchon — Flores des Serres 5: 442, 1849 — recognized, that Central American *Rondeletia* species had terminal paniculate and thyrsoid inflorescences and flowers with bearded or naked throat of corolla, without faucial ring, lamellae or denticles. He observed also a characteristical arachnoid pubescence on the corolla and leaves of several species. Upon these differences Planchon described two genera separated from *Rondeletia* L. — namely *Rogiera* and *Arachnothryx*.

Later both genera have been merged into *Rondeletia* s.l. *Rogiera* was included by Bentham and Hooker (1873) and K. Schumann (1897) without any taxonomic rank. *Arachnothryx* has been considered by the same authors as a section of *Rondeletia*. Standley in his treatment on *Rondeletia* (1918) created a new section for *Rogiera* by the name: *Amoenae* Standl., and divided the *Arachnothryx* into two new sections: *Leucophyllae* Standl. and *Laniflorae* Standl.

The mentioned authors and others dealing with American *Rondeletieae*, as Hemsley, Donnel-Smith, B. L. Robinson etc. paid little attention to the structure of the corolla tube and throat, considering them as features of secondary importance.

In my opinion the structure of the corolla-throat is very important in taxonomical and evolutionary points of view. The structure of the throat, the presence or absence of the faucial ring, its form, pubescence, etc. have an important role in the mechanism of pollination, in the selection of the possible pollinators, in the development of basic plant-animal relationships which may be decisive in the evolution and phylogenetic relations of the different taxonomic groups.

Based upon a comparative morphological examination, Borhidi and Fernandez (1982a and b) determined the chief generic characteristics of *Rondeletia* L. based on *R. americana*. Comparing these characteristics with those of other groups of *Rondeletia*, it turned out, that a close correlation can be found between the different forms of corolla-throat, the structures of placenta and the exine pattern and form of pollen grains.

In consequence of these recognized correlations, it seems necessary to revalidate the genera *Rogiera* and *Arachnothryx* upon the following characterization:

## **Rogiera** Planch. in Fl. Serres 5: 442. 1849

Syn.: *Rondeletia* sect. *Amoenae* Standl. N. Amer. Fl. 32: 49 (1918).

Shrubs or small trees with usually large, foliaceous and reflexed stipules. Leaves opposite, usually large, pubescent or glabrous. Inflorescence broad, terminal, cymose-paniculate or cymose-corymbose, many flowered. Flowers 5-parted, calyx lobes small or large and foliaceous; corolla large, glabrous or antrorse-pilose outside, densely yellow-bearded in the throat, faucial ring, lamelles or denticles absent. Corolla tube puberulent or villous within, stamens included beneath the throat, filaments short, puberulent, anthers elliptic, included in the bearded throat. Style deeply bilobate, naked. Ovary globose, 2-loculate, disk annular naked. Placenta sphaeroidal, little, soft, with a punctiform central insertion to the septum. Ovules numerous, perpendicularly disposed to the placenta. Pollen grains sphaeroidal or subsphaeroidal, 3-colporate, exine thick, densely foveolate with tight irregular foveoles and exerted
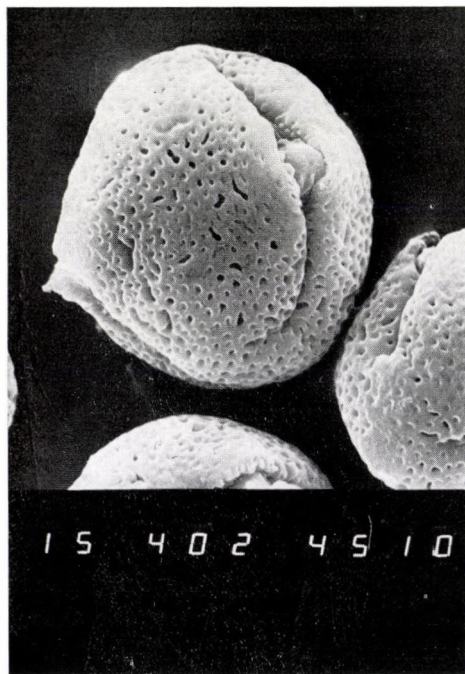
*Fig. 1.* Pollen of *Rogiera ligustroides* (Hemsl.) Borhidi. ×1400 (Scanning-photo made by Dr. K. Vánky)

ora (Fig. 1). Capsula globose, thin, loculicidally dehiscent, 2-valvate. Seed angulate, exappendiculate, not winged.

Species typica: *Rogiera amoena* Planch.

**Rogiera amoena** Planch. Fl. Serres 5: 442 (1849)
Syn.: *Rogiera menechma* Planch. Fl. Serres 5: 442 (1849). — *Rondeletia versicolor* J. Smith Bot. Mag. 4579 (1851). — *Rogiera versicolor* Lindl. et Paxt. Fl. Gard. 2: 69 (1851). — *Rondeletia latifolia* Oerst. Vidensk. Meddel. 1852: 43. — *Rogiera latifolia* Decne. Rev. Hortic. IV. 2: 121 (1853). — *Rondeletia amoena* Hemsley Diagn. Pl. Nov. 26 (1879). — ? *Rondeletia schumanniana* K. Krause Bot. Jahrb. 40: 315 (1908). — Central America

**Rogiera cordata** (Benth.) Planch. Fl. Serres 5: 442*b* (1849)
*Rondeletia cordata* Benth. Pl. Hartw. 85 (1841). — Guatemala

**Rogiera ehrenbergii** (K. Schum.) Borhidi **comb. nova**
*Rondeletia ehrenbergii* K. Schum. N. Amer. Fl. 32: 50 (1918). — Guatemala

**Rogiera gratissima** Linden in Planch Fl. Serres 15: 133 (1864)
*Rogiera elegantissima* Regel Gartenfl. Pl. 490 (1865). — *Rondeletia gratissima* Hemsl. Diagn. Pl. Nov. 25 (1879). — Mexico

**Rogiera intermedia** (Hemsl.) Borhidi **comb. nova**
*Rondeletia intermedia* Hemsl. Diagn. Pl. Nov. 26 (1879). — Mexico

**Rogiera langlassei** (Standl.) Borhidi **comb. nova**
*Rondeletia langlassei* Standley N. Amer. Fl. 32: 53 (1918). — Mexico

**Rogiera ligustroides** (Hemsl.) Borhidi **comb. nova**
*Rondeletia ligustroides* Hemsl. Diagn. Pl. Nov. 26 (1879). — Mexico

**Rogiera pittieri** (Schum. et Krause) Borhidi **comb. nova**
*Rondeletia pittieri* K. Schum. et Krause Bot. Jahrb. 40: 316 (1908). — Costa Rica

**Rogiera roezli** Planch. Fl. Serres 5 : 442 (1849)
*Rogiera elegans* Planch. Fl. Serres 5 : 442 (1849)

**Rogiera stenosiphon** (Hemsl.) Borhidi **comb. nova**
*Rondeletia stenosiphon* Hems. Diagn. Pl. Nov. 26 (1879). — Mexico, Guatemala

**Rogiera strigosa** (Benth.) Borhidi **comb. nova**
*Bouvardia strigosa* Benth. Pl. Hartw. 75 (1841). — *Rondeletia strigosa* Hemsl. Diagn. Pl. Nov. 27 (1879). — Guatemala, Salvador

**Rogiera suffrutescens** (Brand.) Borhidi **comb. nova**
*Rondeletia suffrutescens* Brand. Univ. Calif. Publ. Bot. 6: 70 (1914). — Mexico

## **Arachnothryx** Planchon Fl. Serres 5: 442 (1849)

[Syn.: *Rondeletia* sect. *Arachnothryx* Benth. et Hooker 1873: .... — *Rondeletia* sect. *Leucophyllae* Standl. N. Amer. Fl. 32: 53 (1918). — *Rondeletia* sect. *Laniflorae* Standl. N. Amer. Fl. 32: 55 (1918). — *Rondeletia* sect. *Calycosae* Standl. N. Amer. Fl. 32: 59 (1918).]

Shrubs or small trees with various, usually erect stipules. Leaves opposite, large, usually tomentose or pubescent. Inflorescence terminal, cymose-racemose, cymose-corymbose, paniculate or elongate thyrsiform, rarely capitate, many-flowered. Flowers 4-parted. Calyx lobes short or elongate, narrow or broad, corolla large or small, tube arachnoid tomentose or pubescent outside, puberulous, hirsute or glabrescent within, the throat naked, slightly widened without faucial ring, lamelles or denticles. Stamens 4, subsessile, filaments
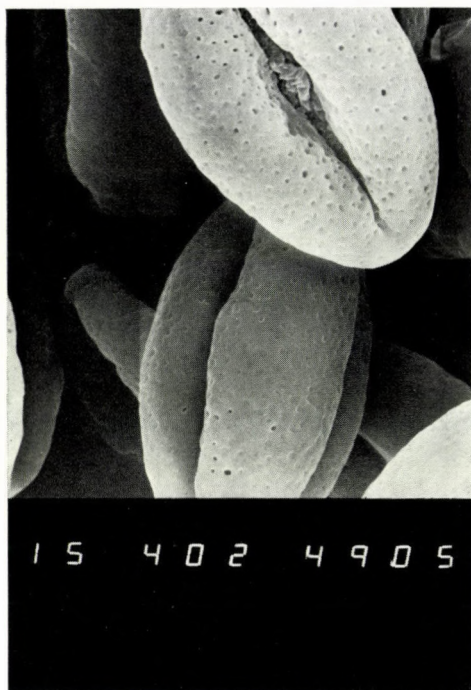
*Fig. 2.* Pollen of *Arachnothrix leucophylla* (HBK.) Planch. ×1400 (Scanning-photo made by Dr. K. VÁNKY)

short, naked, anthers oblong-elliptic, usually included. Pollen grains oblong-elliptic, 3-colporate, exine thick, sparsely foveolate with regular tight and shallow foveoles, sometimes with scattered emergent denticles (Fig. 2). Styles long, naked, shortly bilobate at the apex. Ovary globose or elliptic, small, 2-celled, disk annular slightly lobate, naked. Placenta discoidal or elliptic, concave, thin, not sulcate, with a central insertion to the septum. Ovules numerous, horizontally disposed. Capsule globose or subglobose, small, valls thin, loculicidally dehiscent, 2-valvate. Seeds numerous, angulate, punctulate, brown or yellow, exalate.

Species typica: *Rondeletia leucophylla* H.B.K.

## I. Sectio: **Arachnothryx**

**Arachnothryx aspera** (Standl.) Borhidi **comb. nova**
*Rondeletia aspera* Standley N. Amer. Fl. 32: 54 (1918). — Costa Rica

**Arachnothryx darienensis** (Standl.) Borhidi **comb. nova**
*Rondeletia darienensis* Standley N. Amer. Fl. 32: 53 (1918). — Panama

**Arachnothryx leptodictya** (B. L. Robins.) Borhidi **comb. nova**
*Rondeletia leptodictya* B. L. Robinson Proc. Amer. Acad. 45: 402 (1910). — Mexico

**Arachnothryx leucophylla** (HBK.) Planch. Fl. Serres Ser. I. 5: 442 (1849)
*Rondeletia leucophylla* H. B. K. Nov. Gen. Spec. 3: 395 (1820). — *Rondeletia elongata* Bartl. in DC. Prodr. 4: 409 (1830). — *Bouvardia discolor* H. et A. Bot. Beech. Voy. 428 (1840). — *Arachnothryx elongata* Planch. Fl. Serres 5: 442 (1849). — *Rondeletia dubia* Hemsl. Diagn. Pl. Nov. 28 (1879). — Mexico

**Arachnothryx nitida** (Hemsl.) Borhidi **comb. nova**
*Rondeletia nitida* Hemsl. Diagn. Pl. Nov. 39 (1879). — Mexico

**Arachnothryx rekoi** (Standl.) Borhidi **comb. nova**
*Rondeletia rekoi* Standley Proc. Biol. Soc. Wash. 8: 126 (1918). — Mexico

## II. Sectio: **Laniflorae** (Standl.) Borhidi **comb. nova**

[Sect. *Laniflorae* Standl. sub *Rondeletia* N. Amer. Fl. 32: 55 (1918).]

**Arachnothryx bourgaei** (Standl.) Borhidi **comb. nova**
*Rondeletia bourgaei* Standl. N. Amer. Fl. 32: 56 (1918). — Mexico

**Arachnothryx buddleioides** (Benth.) Planch. Fl. Serres 5: 442 (1849)
*Rondeletia buddleioides* Benth. Pl. Hartw. 69 (1841). — *Rondeletia affinis* Hemsl. Diagn. Pl. Nov. 28 (1879). — Central America

**Arachnothryx capitellata** (Hemsl.) Borhidi **comb. nova**
*Rondeletia capitellata* Hemsl. Diagn. Pl. Nov. 28 (1879). — Mexico

**Arachnothryx cooperi** (Standl.) Borhidi **comb. nova**
*Rondeletia cooperi* Standley Publ. Field. Mus. Nat. Hist. Chicago Bot. Ser. 4: 267 (1929) — Panama

**Arachnothryx gracilis** (Hemsl.) Borhidi **comb. nova**
*Rondeletia gracilis* Hemsl. Diagn. Pl. Nov. 53 (1880). — Guatemala, Honduras

**Arachnothryx inconstans** (Standley) Borhidi **comb. nova**
*Rondeletia inconstans* Standley Publ. Field. Mus. Hist. Nat. Chicago Bot. Ser. 7: 31 (1930) — Columbia

**Arachnothryx heteranthera** (Brand.) Borhidi **comb. nova**
*Rondeletia heteranthera* Brand. Univ. Calif. Publ. Bot. 4: 387 (1913). — Mexico

**Arachnothryx laniflora** (Benth.) Planch. Fl. Serres 5: 442 (1849)
*Rondeletia laniflora* Benth. Pl. Hartw. 85 (1841). — Mexico, Guatemala

**Arachnothryx pansamalana** (Standl.) Borhidi **comb. nova**
*Rondeletia pansamalana* Standl. N. Amer. Fl. 32: 58 (1918). — Guatemala

**Arachnothryx rufescens** (B. L. Robins.) Borhidi **comb. nova**
*Rondeletia rufescens* B. L. Robinson Proc. Amer. Acad. 45: 402 (1910). — *Rondeletia villosa* f. *strigosissima* Donn. Smith. Enum. Plant. Guat. 2: 30 (1891). — *Rondeletia rufescens ovata* B. L. Robins. Proc. Amer. Acad. 45: 403 (1910). — Guatemala

**Arachnothryx secundiflora** (B. L. Robins.) Borhidi **comb. nova**
*Rondeletia secundiflora* B. L. Robins. Proc. Amer. Acad. 45: 403 (1910). — Guatemala

**Arachnothryx septicidalis** (B. L. Robins.) Borhidi **comb. nova**
*Rondeletia septicidalis* (B. L. Robinson Proc. Amer. Acad. 45: 403 (1910). — Mexico

**Arachnothryx stachyoidea** (Donn. Smith) Borhidi **comb. nova**
*Rondeletia stachyoidea* Donn. Smith Bot. Gaz. 43: 298 (1906). — Guatemala, Costa Rica

**Arachnothryx thiemei** (Donn. Smith) Borhidi **comb. nova**
*Rondeletia thiemei* Donn. Smith Bot. Gaz. 42: 299 (1906). — Honduras

**Arachnothryx villosa** (Hemsl.) Borhidi **comb. nova**
*Rondeletia villosa* Hemsl. Diagn. Pl. Nov. 27 (1879). — Mexico

## III. Sectio: **Calycosae** (Standl.) Borhidi **comb. nova**

[Sect. *Calycosae* Standl. sub *Rondeletia*, N. Amer. Fl. 32: 59 (1918).]

**Arachnothryx aetheocalymna** (Donn. Smith) Borhidi **comb. nova**
*Rondeletia aetheocalymna* Donn. Smith Bot. Gaz. 43: 298 (1906). — Guatemala
**Arachnothryx belizensis** (Standley) Borhidi **comb. nova**
*Rondeletia belizensis* Standley Publ. Carnegie Inst. Wash. No. 461: 91 (1935) — Guatemala, Honduras
**Arachnothryx bertieroides** (Standl.) Borhidi **comb. nova**
*Rondeletia bertieroides* Standley Publ. Field. Col. Mus. Bot. Ser. 4: 267 (1929) — Panama
**Arachnothryx brevicollis** (Kirkbr.) Borhidi **comb.** et **stat. nov.**
*Rondeletia salicifolia* ssp. *brevicolla* Kirkbride Ann. Mo. Bot. Gard. 55: 383 (1963) — Panama (**brevicolla**" does not exist in Latin, exactly: **brevicollis**)
**Arachnothryx calycosa** (Donn. Smith) Borhidi **comb. nova**
*Rondeletia calycosa* Donn. Smith. Bot. Gaz. 56: 59 (1913). — Costa Rica
**Arachnothryx costaricensis** (Standl.) Borhidi **comb. nova**
*Rondeletia costaricensis* Standl. N. Amer. Fl. 32: 61 (1918). — Costa Rica
**Arachnothryx darcyi** (Dwyer) Borhidi **comb. nova**
*Rondeletia darcyi* Dwyer Ann. Mo. Bot. Gard. 67: 467 (1980) — Panama
**Arachnothryx deamii** (Donn. Smith) Borhidi **comb. nova**
*Bouvardia deamii* Donn. Smith Bot. Gaz. 49: 455 (1910). — *Rondeletia deamii* Standley N. Amer. Fl. 32: 60 (1918). — Mexico, Guatemala
**Arachnothryx galeotti** (Standl.) Borhidi **comb. nova**
*Rondeletia galeotti* Standl. N. Amer. Fl. 32: 59 (1918). — Mexico
**Arachnothryx hameliifolia** (Dwyer et Hayden) Borhidi **comb. nova**
*Rondeletia hameliifolia* Dwyer et Hayden Ann. Miss. Bot. Gard. 65 : 144 (1967) — Panama
**Arachnothryx jurgenseni** (Hemsl.) Borhidi **comb. nova**
*Rondeletia jurgenseni* Hemsl. Diagn. Pl. Nov. 29 (1879). — Mexico
**Arachnothryx kirkbridei** (Dwyer) Borhidi **comb. nova**
*Rondeletia kirkbridei* Dwyer Ann. Mo. Bot. Gard. 67: 469 (1980) — Panama
**Arachnothryx platysepala** (Standl.) Borhidi comb. nova
*Rondeletia platysepala* Standley Ann. Mo. Bot. Gard. 27: 343 (1940) — Panama
**Arachnothryx linguiformis** (Hemsl.) Borhidi **comb. nova**
*Rondeletia linguiformis* Hemsl. Diagn. Pl. Nov. 29 (1879). — Guatemala
**Arachnothryx rosea** Linden, Hort. Linden. (1859) 3. — N. Granat.
**Arachnothryx salicifolia** (Dwyer et Hayden) Borhidi **comb. nova**
*Rondeletia salicifolia* Dwyer et Hayden Phytologia 15 : 58 (1967) — Panama
**Arachnothryx secunda** (Standl.) Borhidi **comb. nova**
*Rondeletia secunda* Standley Contr. U. S. Nat. Herb. 18: 141 (1916). — Panama

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# CAMBIAL ACTIVITY IN *MANGIFERA INDICA* L.

Y. S. Dave and K. S. Rao

DEPARTMENT OF BIOSCIENCES, SARDAR PATEL UNIVERSITY, INDIA

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Cambial activity in *Mangifera indica* L. has been studied from January 1978 to December 1978. Cambium is nonstoried comprising elongated fusiform and isodiametric ray initials. Radial growth in the trees is continuous as the cambium is active in all the months. However, more cambial activity is noticed in the later part of the year. Tangential divisions in the cambial zone leads to the differentiation of vascular elements. The length and width of fusiform initials vary in different months. The variations in the mean length of fusiform initials show a close relationship with that of xylem fibers. Climatic factors do not show any relation with the activity of the cambium.

## Introduction

Now it has become a well-known fact that the environmental changes are closely associated with a regular sequence of growth and dormancy in most plants. Trees growing in regions with temperate climate show distinct growth rings. Tropical woody plants are considered to have a long period of cambial activity and in some of them cambial cells usually divide and develop into vascular elements at more or less uniform rate throughout the year (Fahn 1977). There are conflicting reports about the periodicity of wood formation in tropical trees. The ringless trees in the rain forest of India was reported 75% (Chowdhury 1961), in the rain forest of Amazon basin 43% (Alvim 1964) and in Malaysia only 15% of the species showed continuous radial growth (Koriba 1958). The formation of growth rings in some tropical deciduous (Coster 1927–28) and evergreen trees has been studied.

The present work has been undertaken to study the activity of the cambium in *Mangifera indica*, an evergreen, diffuse porous tropical tree and is an addition to our previous reports on seasonal activity of cambium in deciduous species (Rao and Dave, 1981, Dave and Rao 1981).

## Materials and methods

Samples of cambial tissue together with the outer wood and inner bark were collected from the main trunks at chest height of six trees of *Mangifera indica* L. growing in university botanical garden at Vallabh Vidyanagar (22°34′ N 72°56′ E). Simultaneously small pieces of young branches (measuring 10 mm diameter) were also collected. Periodic collections were made from January 1978 to December 1978 in the first week of every month. The procedure used for sampling, sectioning, staining and study of the material was same as those described earlier in detail by Rao and Dave (1981). Meteorological data was obtained from the Indian Meteorological Department, Ahmedabad in Gujarat State of India.

## Results

### *Cambium structure*

Cambium is nonstoried comprising vertically elongated fusiform initials with tapering ends and isodiametric ray initials (Fig. 1A). Cambial initials are uninucleate and each nucleus possesses one to two nucleoli. Vascular cambium is active in all the months with the dif-
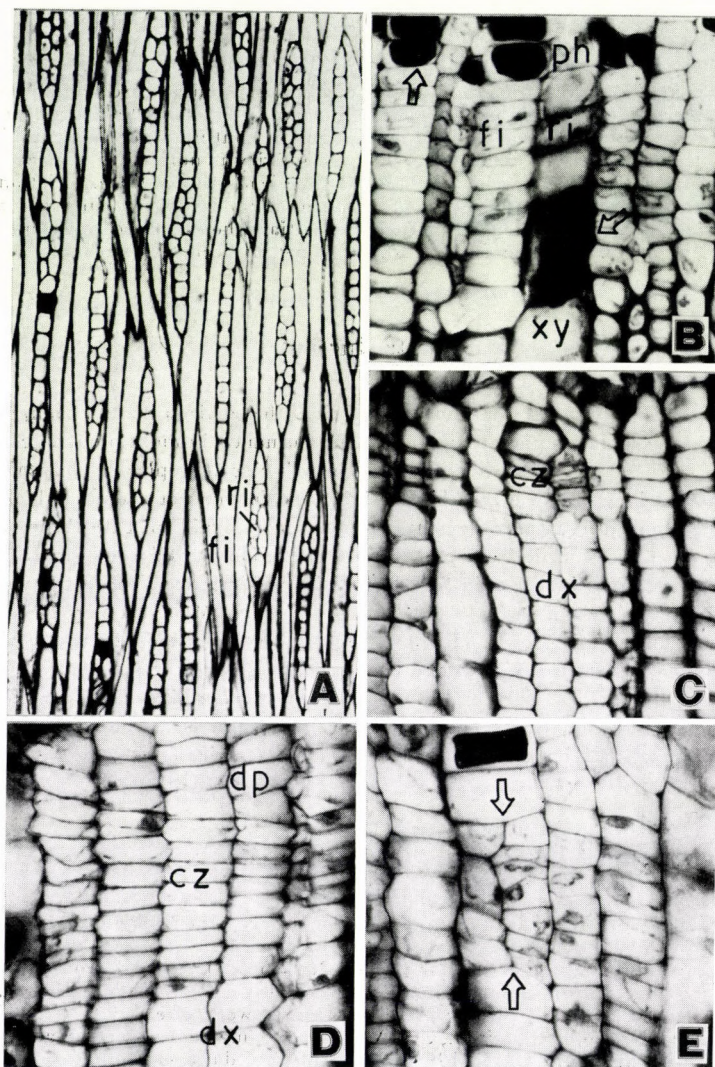
*Fig. 1.* Tangential (A) and transverse (B–E) sections of cambium of *Mangifera indica*. — A) Cambium showing nonstoried arrangement of fusiform and ray initials. ×150. — B) Cambial zone in January. Arrows indicate tannin contents in vascular cells. ×350. — C) Cambium showing the radial seriation of differentiating xylem elements. ×350. — D) Cambial zone in October showing differentiating xylem and phloem cells. ×530. — E) Cambial zone in November showing a radial file with anticlinally divided fusiform cells (at arrows). ×670. — *cz:* cambial zone; *dp:* differentiating phloem elements; *dx:* differentiating xylem elements; *fi:* fusiform initial; *ph:* phloem; *ri:* ray initial; *xy:* xylem

ferentiating derivatives towards xylem and phloem (Figs 1B–E, 2). Secondary xylem and phloem are formed by periclinal divisions of cambial cells; anticlinal division lead to an increase in circumference of the cambium (Fig. 1E). Cambial cell walls are thin with inconspicuous beaded nature. Cambial rays are predominantly biseriate. The fusiform initials constitute 76 to 81% of the total cambial tissue.

## *Cambial activity*

Cambium is active throughout the year with no period of dormancy. Periclinal divisions in the cambial cells occur continuously and the resulting cells undergo gradual differentiation to form xylem and phloem elements (Fig. 1C, D). However, the rate of cambial activity varying periodically is indicated by the number of cells in the cambial zone and differentiating vascular elements (Fig. 2). Cambial activity is considerably high from September to December (Fig. 1D, E). In the young branch also cambium shows continued activity with more activity in October (Fig. 2).

## *Cell size variation*

The length and tangential width of fusiform initials undergo changes during activity of the cambium and ranges from 349 to 428 $\mu$m and 20 to 23 $\mu$m respectively (Fig. 3). The increase and decrease in width correspond to the decrease and increase in length of fusiform initials in all the months except September and October (Fig. 3). The changes in the length of fusiform initials and xylem fibers are closely related throughout the year (Fig. 3). However, the mean length of xylem fibers is greater and is 1.9 to 2.5 times longer than fusiform initials. The tangential diameter of ray initials ranges from 16.0 to 20.6 $\mu$m. The height and width of cambial rays ranges from 226 to 290 $\mu$m and 22.8 to 36.5 $\mu$m respectively.
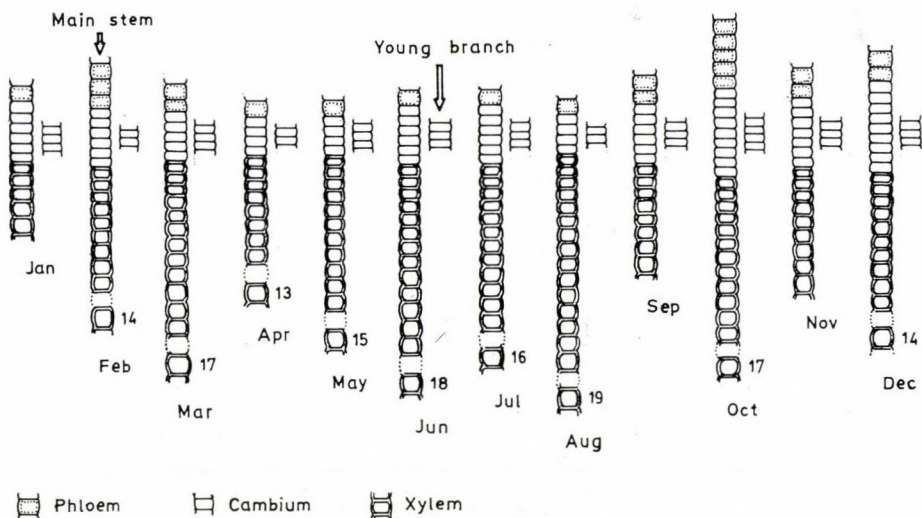
*Fig. 2.* Schematic diagram illustrating the seasonal variation in the mean number of cell layers in the cambial zone in the main trunk and young branch and differentiating xylem and phloem elements in the main trunk
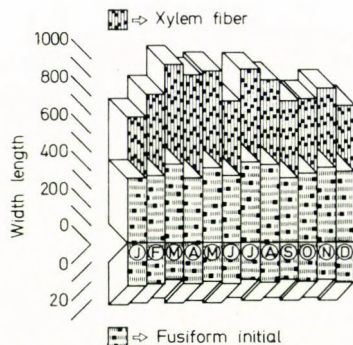
*Fig. 3.* **Histograms showing the seasonal variations in mean length of xylem fibers and length and width of fusiform initials in $\mu$m**
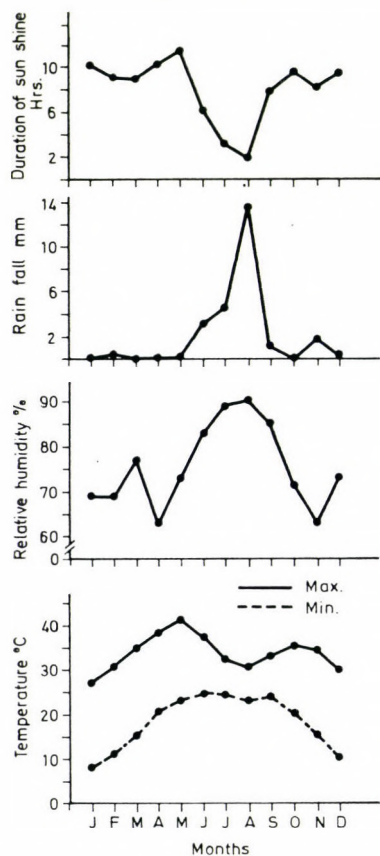
*Fig. 4.* A graphic representation of meteorological data of Vallabh Vidyanagar during the year 1978

### *Development of vascular tissues*

Since the cambium is active throughout the year, the differentiation of vascular elements occurs continuously (Fig. 2). The derivatives of fusiform initials undergo radial enlargement and occur in radial rows towards xylem (Fig. 1C). The derivatives of ray initials undergo relatively little change during differentiation, but enlarge radially. The differentiation of xylem is faster than phloem. The rate of differentiation of vascular elements is not paralleled by the rate of divisions in the cambial zone. The number of differentiating elements of xylem in August and phloem in October is maximal. The new phloem cells mature rapidly and the cambial zone remains close to phloem. Phloem parenchyma and xylem ray cells adjacent to cambium possess tannin contents (Fig. 1B).

### *Cambial activity in relation to phenology and climatic factors*

As an evergreen tree, *Mangifera* bears leaves all the year around. Trees flower in March. Young shoots arise from older branches from June to August and in the following months cambium shows more activity.

Rainfall and air temperature are interdependent factors, the latter reaching the peak in May at the end of dry period, when the number of daily sunshine hours is also at maximum. With the start of rains in June, air temperature begins to fall, reaching minimum in August when the rains are heavy (Fig. 4). Flowering resulted in March when the average maximum temperature is 35 °C. The variation in temperature and duration of sunshine hours do not bring any change in cambial activity. During the development of young leaves from older branches relative humidity and rainfall are considerably high.

## Discussion

The relative number of fusiform and ray initials in the cambial zone varies considerably. KOZLOWSKI (1971) generalized that more than 90% of the cambium is composed of fusiform initials. In the present study the proportion of fusiform initials in the cambial zone varies from 76 to 81% as also been noted in some Indian tropical trees (GHOUSE and YUNUS 1974, 1976). The wide variations in the ratio of fusiform and ray initials in the cambial zone of different plants is probably related to the differences in vigour, growth, girth and age of the species investigated.

The pattern of radial growth is paralleled by the width of cambial zone which increases, remains constant and then declines with the rate of cell production (PHILIPSON, WARD and BUTTERFIELD 1971). The rate of cambial cell division in *Mangifera* is not paralleled by the rate of differentiation of vascular elements in all the months. In August, when the cambium is four layered, the differentiating xylem elements occur in maximum number. In September, the differentiating xylem elements decreases, while the cambial cell number increases. The number of both the vascular elements increases in October when the cambium is with maximum number of cells. WILSON (1966) found that the variation in the number of cell across the cambial zone seems

to reflect a balance between the rate of cell division and the rate of differentiation of new derivatives.

Changes in the length of fusiform initials are just one aspect of the profound modifications which takes place in the cambial zone during the life of plants (CATESSON 1974). In *Mangifera*, the length of fusiform initials differ in different months and the increase in the mean length corresponds with the decrease in the mean width or vice versa. While this kind of relationship does not exist between the length and width of fusiform initials of *Tectona* (RAO and DAVE 1981) and *Gmelina* (DAVE and RAO 1981).

Only limited attempts have been made to establish the size relationship between cambial initials and the elements produced by them (SHARMA et al. 1979). In the present study the periodic variations in the length of fusiform initials correspond to that of xylem fibers as also been noted in *Tectona* (RAO and DAVE 1981) and *Gmelina* (DAVE and RAO 1981). This correlation exists throughout the year as the cambial cells leave a record of their activities in their derivatives. CHATTAWAY (1936) has observed that the fibers in dicotyledonous wood are 1.1 to 9.5 times longer than the cambial initials. The xylem fibers in *Mangifera* are 1.9 to 2.5 times longer than fusiform initials. The fiber elongation is less in comparison with *Tectona* (RAO and DAVE 1981) and *Gmelina* (DAVE and RAO 1981). The less elongation of fibers probably related with the continuous activity of the cambium.

There are plants in which the cambium is active throughout the year and this type of activity is usually found in plants growing in tropical regions (FAHN 1977). Being an evergreen species *Mangifera* showed continuous activity of the cambium throughout the year 1978. However, all the evergreen trees do not show continued cambial activity. Cambium is found to be dormant for a short period in an evergreen tropical *Psidium guajava* (CHOU and CHIANG 1973) and *Liquidambar formosana* (LU and CHIANG 1975). In *Mangifera*, the correlation between extension growth and cambial activity is not clear like certain evergreen trees (CHOWDHURY 1958, FAHN et al. 1968). The enhanced activity of the cambium in the later part of the year may be due to the development of young leaves from older branches during rains. The interval between shoot growth flushes of mango sometimes exceeding 12 months (KRAMER and KOZLOWSKI 1979) may be the probable reason for the lack of shoot growth in the *Mangifera* of present study. However, more studies are essential to get a comprehensive idea on the pattern of cambial activity in evergreen tropical trees.

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# RUBIACEAS CUBANAS II–III

## II. EL GÉNERO CASASIA A. RICH. EN CUBA
## III. NOVEDADES EN EL GÉNERO ANTIRHEA COMMERS.

M. FERNANDEZ ZEQUEIRA[1] y A. BORHIDI[2]

[1] INSTITUTO DE BOTÁNICA ACADEMIA DE CIENCIAS DE CUBA, LA HABANA
[2] INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE HUNGRÍA, VÁCRÁTÓT, HUNGRÍA

(Llegado: 1 de Octubre 1981)

A new species of *Casasia* — *C. acunae* Fernandez et Borhidi — is described and its morphological discrimination from *C. jacquinioides* (Griseb.) Standl. A new analytic key for determination of the Cuban taxa is also presented. In the genus *Antirhea* a taxonomic revision of a polymorphic species — *A. abbreviata* Urb. — was carried out. It resulted a new status: *Antirhea abbreviata* ssp. *obcordata* (Alain) Borhidi et Fernandez and the description of a new variety: var. *moaensis* Fernandez. Another new *Antirhea* species: *A. pedicellaris* Borhidi et Bisse from the affinity of *A. multinervis* Urb. is also described.

### El género Casasia A. Rich. en Cuba

*Casasia* A. Richard in Sagra: Hist. Fis. Pol. Nat. Cuba XI.: 9. 1850.

Arbustos o árboles con hojas opuestas y estipulas persistentes. Inflorescencia terminal, cimosa, flores comunmente grandes, blancas, 5-meras o raras veces 4-meras. Tubo del cáliz turbinado, el limbo cupuliforme, lóbulos subulados o triangulares, persistentes. Corola asalvillada, mayormente glabra por fuera, el tubo alargado, cilindrico, lóbulos coriáceos, contortos, (4)–5. Estambres 4 o 5, insertos en la garganta de la corola; filamentos muy cortos, anteras dorsífijas, inclusas. Disco anular; ovario 2-locular, estilo incluso, con dos lóbulos lineares. Ovulos numerosos, placentas parietales. Fruto en baya grande globosa o piriforme; pericarpio grueso y duro. Semillas numerosas, grandes, horizontales, reticuladas. Endospermio córneo. Género endémico de las Indias Occidentales con 9–10 espécies en Cuba, Jamaica, Española y en las Bahamas.

Clave analitica para los taxones cubanos:

1 a Nervios laterales de las hojas muchos, muy unidos entre si y paralelos 2
  b Nervios laterales de las hojas menos, numerosos, separados, no paralelos ........................................................ 3
2 a Hojas glabras, el margen plano .................... 1. *C. calophylla*
  b Hojas aterciopeladas en el envés, el margen revoluto .. 2. *C. nigrescens*
  ba Hojas de 3.5–8.5 cm de largo de 0.7–2 cm de ancho, oblongo-lanceoladas, fruto de 2.5–4 cm de diámetro.............. 2/a ssp. *nigrescens*
  bb Hojas de 7–11 cm de largo, y de 2–4.5 cm de ancho, obovadas, fruto de 4–7 cm de diámetro .......................... 2/b ssp. *moaensis*
3 a Hojas de 3–14 cm de ancho, fruto de 5–7 cm ......... 3. *C. clusiifolia*

aa Hojas e inflorescencia glabras ............... 3/a var. *clusiifolia*
ab Inflorescencia y hojas en los nervios del envés hirsutos ............
........................................... 3/b var. *hirsuta*
b Hojas de hasta 1.5 cm de ancho, fruto de 1–1.5 cm .............. 4
4 a Hojas lanceoladas de 1.5–3.3 cm de largo, flores mayormente 4-meras, lóbulos del cáliz aovados, alargados en el fruto de 1–2 cm de largo .....
........................................... 4. *C. jacquinioides*
b Hojas obovadas a rómbeas de 0.5–1.5 cm de largo, flores mayormente 5-meras, lóbulos del cáliz subulados, no alargados en el fruto de 0.5–1 cm de largo ........................................... 5. *C. acunae*

1. **C. calophylla** A. Rich. in Sagra Hist. Fis. Pol. Nat. Cuba XI: 9 (1850). Typus: VALENZUELA s. n. Pinar del Rio: Vuelta de Abajo (P). Distribución: Bosques semideciduos y deciduos, matorrales costeros, mayormente sobre caliza, en toda Cuba e Isla de Pinos. Meso- y Micro-fanerófito, notófilo.
2. **C. nigrescens** (Griseb.) Wr. in Urb. Symb. Ant. 5: 505 (1908). Basiónimo: *Randia nigrescens* Griseb. Cat. Plant. Cub. 1866: 123; typus: WRIGHT 2659. Sierra de Nipe, Pinal de Mayari. Distribución: Matorrales serpentinosos de las montañas del Norte de Oriente, Cuba; endémica.
   a) **ssp. nigrescens,** endémica de las Sierras de Nipe y Cristal; nanofanerófito, micrófilo.
   b) **ssp. moaensis** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. 17: 31 (1971), fototipo: Acta Bot. Acad. Sci. Hung. 18: 46 (1973). Typus: BORHIDI, MUÑIZ et VAZQUEZ HAC. s. n. Endémica en la Sierra de Moa, Cuchillas de Toa y Baracoa. Nanófito, notófilo.
3. **C. clusiifolia** (Jacq.) Urb. Symb. Ant. 5: 505 (1908). Basiónimo: *Gardenia clusiifolia* Jacquin Coll. V. Suppl. 1796: 37. tab. 4. fig. 3. Distribución: Matorrales costeros en Cuba, Florida, Bahamas y Bermuda. Micro- y nanofanerófito, meso- y notófilo.
   a) **var. clusiifolia,** en toda el area.
   b) **var. hirsuta** Borhidi Abstracta Bot. Univ. Budapest 5: 43 (1977). Typus: 27768 SV HAC, Oriente: Gibara. Distribución: Costa Norte de Oriente.
4. **C. jacquinioides** (Griseb.) Standl. Contr. U. S. Nat. Herb. 20: 208 (1919). Basiónimo: *Alibertia jacquinioides* Griseb. Cat. Plant. Cub. 1866: 123. Typus: WRIGHT 2663, Baracoa. Distribución: Matorrales serpentinosos de las montañas del Norte de Oriente, Cuba, endémica. Nanofanerófito, micrófilo. Sinónimo: *C. parvifolia* Britt. Bull. Torr. Bot. Club 43: 461 (1916).

*Descripción complementaria*:

Arbustos, ramitas escabrositas cuando jóvenes, estípulas deltoides acuminados, de 1–3 mm, pubérulos cuando jóvenes, hojas oblanceolado-oblongas a oblongo obovadas u obovadas, de 1.5–3.3 cm de largo por 0.6–1.2 cm de ancho, estrechadas hacia la base, redondeadas agudi-tas en el ápice, con un pequeño mucrón, coriáceas, glabras, el margen revoluto. Nervio medio hundido en el haz, fuertemente prominente y engrosado hacia la base del envés, los laterales 5–7 pares prominentes y anastomosados en ambas caras. Corola y cáliz tetrámeros. Lóbulos del cáliz triangulares a ovales, de 0.5 mm de largo próximos e iguales. Tubo del cáliz de 1.5 mm de largo, peloso por fuera. Corola de 7–8 mm de largo, glabra. Tubo de la corola de 4.5–5 mm de largo, lóbulos oblongo-aovados oblanceolados agudos y apiculados en el ápice de 3–4 mm de largo. Estambres de 2 mm de largo, insertos en el tubo de la corola. Filamentes muy cortos, adnatos en el cuarto inferior de la corola. Anteras lineales de 3 mm de largo, brevemente bilobulados en la base, el conective apiculado en el ápice. Estilo 4 mm de largo, ligera-

*Fig. 1.* Holotipo de *Casasia clusiifolia* (Jacq.) Urb. var. *hirsuta* Borhidi (27768 HAC)

mente ensanchado. Ovario obovado, de 1.2–1.5 mm largo, ligeramente comprimido, muy poco turbinado, obtusamente cuadrangular, peleso por fuera, poco lobulado bilucular y glabro en el ápice. Fruto globoso de 0.9–1.4 cm de largo por 0.9–1.2 cm de diámetro. Cáliz persistente en el fruto, lóbulos oblongo-aovados alargados durante la maduración del fruto.

5. **Casasia acunae** Fernandez et Borhidi **sp. n.**

Frutex dense ramificatus. Ramuli hornotini teretes, dense breviterque hirsuti, veteriores cinerei vel albi, longitudinaliter fissurati, glabri. Stipulae late triangulares usque ad 1 mm longae, acutae et breviter acuminatae, hirsutae. Folia conferta vel in brachyblastis fasciculata, subsessiles vel usque ad 1 mm longe petiolata, late obovata vel rariter rhombea, basi cuneata et in petiolum protracta, apice plerumque rotundata, truncata vel obtusa, apice emarginata vel obtusa, brevissime mucronulata, 0,5–1,8 cm longa, et 0,3–1,0 cm lata, nervo medio supra impresso, subtus prominente, lateralibus utroque latere 3–5, utrinque prominentibus, anastomosantibus et ante marginem conjunctis; supra lucida subtus nitidula et pallida, utrinque glabra margine recurva vel revoluta, coriacea. Flores 5-meri plerumque solitarii axillares vel

subterminales, sessiles. Hypanthium obovatum, puberulum, 2 mm longum, tubus calycis latus, puberulus, margine membranaceus 1,2–1,5 mm longus, lobi 5, leviter inaequales, distantes, subulati 0,5–1 mm longi, dorso puberuli, plerumque leviter recurvati. Corolla coriacea, extus glabra 7–8 mm longa, tubus 5–6 mm longus, sub lobis 2 mm latus, lobi 5, late triangulares acuti 2–2,5 mm longi. Stamina 5, tubi corollae inserti, filamenta brevia usque ad 1 mm longa, in 1/3 inferiori tubi corollae adnata, antherae oblongo lineares, 3 mm longae, basi breviter auriculato-bilobatae, apice apiculatae. Stylus 5 mm longus, apice dilatatus, rhomboideo acutus. Ovarium compressum turbinatum, leviter 3-lobulatum, obovatum 2-loculare, extus pilosum, vertice glabrum. Fructus globosus apice lobis calycinis coronatus, 5–10 mm longus sine calyce, 5–9 mm in diametro, extus squamatus, lobi calycis non crescentes sub maturitate fructus.

Holotypus: Cuba, Oriente (Prov. Holguin) Moa; leg.: Sra. BUCHER No. 126, Nov. 1939 SV/HAC !

Isotypi: Roig 8202 SV/HAC !, 11454 SV/HAC !

Paratypi: CLEMENTE 6895, Camino de Centeno, Cananova, Moa; leg.: CLEMENTE, ALAIN et CHRISOGONE, Julio 1949 SV/HAC ! Se encuentra ésta especie, en la zona de los latosoles de

*Fig. 2.* Ejemplar fructificado de la *Casasia jacquinioides* (Griseb.) Standl.

*Fig. 3.* Ejemplar fructificado de la *Casasia acunae* Fernandez et Borhidi (Clemente 6895 HAC)

serpentina de la zona subcostera de Moa. Basándonos en los datos actuales se puede considerarla como una especie endémica de esa región.

Tipo ecológico: Nanofanerófito, nanófilo.

## Novedades en el género Antirhea Commers.

El género *Antirhea* Commers, es un género de distribución pantropical, tiene unas 40–45 especies representadas en las Antillas, América Central, Asia Tropical y Madagascar. En Cuba viven 20 especies, de ellas 15 son endémicas, hecho que permite considerar el Archipiélago cubano como un centro de evolución del género.

Alain (1964), en el tomo V. de la Flora de Cuba, presenta 17 especies con clave analitica y descripciones cortas. El trabajo taxonómico critico preliminar realizado por los autores, permitió describir nuevos taxones para la ciencia. A continuación se describen los mismos:

**Antirhea abbreviata** Urb. Symbolae Antillanae 9: 159 (1923).

Typus: EKMAN 9523, Nipe: Rio Piloto. (S)

Arbusto, ramitas glabras o casi, resinosas; estipulas triangulares, coriáceas glabras a pelosas hasta de 3 mm; hojas oblanceolasas, oblongo abovadas, anchamente obovadas, suborbiculares a obcordiformes de 1.1–2.8 cm de largo por 0.8–3.5 cm de ancho, atenuadas, obtusas o reondeadas a truncadas y emarginadas el ápice, algo estrechadas a subobtusas o agudas en la base, coriáceas; pelositas en el margen en el haz y en el nervic medio del envés, margen recurvo.

Inflorescencia 1–2 flora, peduncular de 1–4 mm, cáliz de 3–4 mm, lóbulos semiorbiculares o anchamente triangulares, cotos, a ceccs el limbo subtruncado, escabroso y poco ondulados en el margen. Corola blanca, el tubo de 10–13 mm, peloso por dentro, lóbulos 5, obovados a aovados de 2–4 mm, estambres 5, incluidos en la garganta de la corola, insertos, filamentos cortos de 0.2–1 mm; anteras lineal lanceoladas, subsentados de 3 mm de largo, dorsifijas en el tercio inferior; ovario 1–4 locular; estilo de 3 mm de largo, el ápice triangular el estigma bilobulado; fruto elíptico-oblongo, coronado por los lóbulos del cáliz persistentes, hasta de 1.1 cm de largo sin el cáliz y hasta 1.5 cm de largo con el cáliz y de hasta 0.6 mm de ancho.

Esta especie se encuentra en los matorrales siempreverdes de serpentina del N. de la parte más oriental de Cuba, donde presenta una cierta variabilidad, condicionada aparentemente por su distribución geográfica en las distintas montanas de esta zona. Para precisar el carácter morfológico de ésta variabilidad se realizaron mediciones de largo y ancho de hojad y frutos, procesándolas y evaluándolas posteriormente. Al analizar el comportamiento gráfico de la distribución de las mediciones en esta especie, vemos que se distinguen 2 grupos de poblaciones según los valores encontrados en el indice relación largo/ancho de hojas.

Las hojas de los ejemplares colectados en las sierras de Nipe y Cristal, que representan la forma tipica de la especie, son más alargadas, oblanceoladas a elipticas, distinguiéndose bien de la forma obovada o anchmente obovada, a veces obcordada, que presentan las hojas de los ejemplares analizados de la zona de Moa. El hecho que esta diferencia morfológica se presenta conscuentemente en los individuos de los dos grupos mencionados, nos hace considerar, que éstos grupos representan dos taxones infraespecificos morfológicamente marcados y geográficamente delimitados, en el rango de subespécie. En la zona de las Cuchillas de Baracoa se colectaron ejemplares estériles que tienen hojas elipticas, mucho más grandes que las de las zonas antes mencionadas y posiblemente corresponde a otro nuevo taxon infraespecifico de la especie **A. abbreviata.**

## A. abbreviata

La subdivisión taxonómica de esta especies es la que sigue:

**Antirhea abbreviata** Urb. ssp. **abbreviata**

Folia oblanceolata, elliptica vel leviter oblonga, 1.3–4 cm longa et 0.8–1.9 cm lata, longitudo latitudinem 1.8–2.4-plo superans, apice attenuata, obtusa vel rotundata.

Area: Sierras de Nipe y Cristal. Provincia Holguin y N. de Stgo de Cuba. Endémica.

ssp. **abbreviata:** hojas oblanceoladas, elipticas o ligermente oblongas, de 1.3–4 cm de largo y 0.8–1.9 cm de ancho, la relación largo/ancho es de 1.8–2.4; el ápice atenuado, obtuso a redondeado.

**Antirhea abbreviata** Urb. ssp. **obcordata** (Alain) Borhidi et Fernandez **status novus.**

Basionymon: *Antirhea obcordata* Alain Candollea 17: 108, 1960

Synon: *Antirhea abbreviata* var. *obcordata* (Alain) Borhidi Bot. Közlem. 58: 177 (1971)

A typo differt: foliis obovatis, late obovatis rariter suborbicularibus vel obcordatis, 1.1–3.5–(4.8) cm longis et 0.9–3.5 latis, longitudinibus latitudinem 1.2–1.8-plo superantibus, ápice rotundatis, truncatis vel emarginatis.

Area: Sierras de Moa y Toa. Provincias: Holguin y Guantánamo. Endémica.

ssp. **obcordata** (Alain) Borhidi et Fernández

Difiere del tipo, en tener hojas obovadas, anchamente obovadas, raramente suborbiculares a obcordiformes de 1.1–3–5 (4.8) cm de largo por 0.9–3.5 cm de ancho; la relación largo/ancho está entre 1.2–1.8; el ápice redondeado, truncado o emarginado.

Dentro de esta subespecie se distinguen 2 variedados, que son las siguintes:

Var. **obcordata:** foliis obcordatis, apice truncatis et emarginatis, basi attenuatis.

Var. **obcordata:** hojas obcordiformes, el ápice truncado y claramente emarginado, largamente atenuadas en la base.

Var. **moaensis** Fernandez **var. nova**

A var. **obcordata** differt foliis obvatis vel suborbicularibus, apice rotundatis vel subtruncatis, non emarginatis, basi obtusiusculis.

Holotypus: Clemente 3639: Moa, Yagrumaje de Arriba, Prov. Holguin Leg.: H. Clemente, mai. 1944 HAC !

Var. **moaensis** Fernandez, difiere de la variedad *obcordata* en tener hojas obovadas o suborbiculares, redondeadas o subtruncadas, no emarginadas en el ápice, ligeramente obtusas en la base.

Nota: En el caso de la ssp. *obcordata* aplicamos el nombre propuesto por Alain con prioridad, en sentido amplio, incluyendo las otras formas de esta subespecie (ejemplares de var. *moaensis*) que existen en Moa, teniendo en cuenta que el taxon descrito por Alain representa una forma extrema de la subespecie caracteristica para la zona de Moa.

**Antirhea pedicellaris** Borhidi et Bisse **sp. n.**

Frutex. Rami hornotini 4-anguli, longitudinaliter striati, minutissime puberuli, veteriores teretes, cinerei, lenticellati et transversaliter fissurati, glabri. Stipulae interpetiolares late ovatae, superne acuminato-subulatae et 1 mm longe mucronatae, 3–4 mm longae, dense pulverulento-pilasae, valde deciduae. Folia 3–15 mm longe petiolatae, petiolis pulverulento-pilosis suffulta, oblongo-obovata, inferne longe attenuata, cuneata et in petiolum protracta, apice rotundata, rariter subtruncata et brevissime emarginata, 2.5–7 cm longa et 0.8–3 cm lata;

*Fig. 4.* Holotipo del *Antirhea pedicellaris* Borhidi et Bisse (17793 HAJB)

nervo medio supra inferne applanato, superne in sulco leviter prominulo, sub apice evanescente, subtus prominente, lateralibus numerosissimis sum angulo 70° abeuntibus, utrinque prominulis et dense minuteque reticulatis, margine angustissime recurva utrinque nitida, glabra chartacea. Inflorescentiae axillares 0,8–3 cm longe pedunculatae, minute laxeque puberulae, semel bifurcatae, ramis 1,5–4 cm longis, laxe 6–11 floris; pedicolli 1,5–4,5 mm longi, patentes, pilosiusculi. Calycis tubus cum hypanthio obovatus, 1,8–2 mm longus, glaber, superne 1–1,2 mm latus, lobi 5, late ovati vel subtruncati, cca 0,2–0,4 mm longi, margine pilosi. Corolla non visa. Fructus drupaceus obovatus, 7–8 mm longus et 4 mm latus, niger, glaber, apice lobis calcycinis margine pilosis coronatus, lateraliter compressus, basin versus leviter costatus, 2-spermus. Semina cylindracea, lineari-oblonga, 4 mm longa et 0,5 mm lata, 4-costata, apice incrassata, basi attenuata.

Holotypus: 17793 HAJB; Prov. Holguin; Monte la Breña, en pluvisilvas montanas a 300–500 m de altura, Moa. Col.: J. Bisse et H. Lippold, 12, 8, 1970. Isotypus: JE.

Obs: Forma, nervatione foliorum et habitu A. *multinervis* Urb. affinis, sed floribus manifeste pedicellatis inter omnes species huius generis insignis.

Esta especie es parecida a la *Antirhea multinervis* Urb. en cuanto al aspecto general, forma y nerviación de las hojas, pero es la única especie del género que tiene flores pediceladas. Hasta ahora no ha sido colectada otra vez. Probablemente es endémica de la Sierra de Moa.

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# EGERIAN (UPPER OLIGOCENE) MACROFLORA FROM VERŐCEMAROS (HUNGARY)

L. HABLY

BOTANICAL DEPARTMENT OF THE NATURAL MUSEUM OF HUNGARY, BUDAPEST, HUNGARY

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The author deals with a newly discovered Egerian flora locality in Hungary and describes a new species: *Debeya hungarica* sp. n. Other species of this genus have become known sofar from the Eocene and the Cretaceous. The finding in Verőcemaros can be considered to be a relic which is supported also by the fact that the flora is more thermophilous than the Hungarian Egerian floras.

## Introduction

There is a small but very interesting palaeobotanical material in the Hungarian Natural Museum, Budapest collected by Á. BOROS in 1973. The remains — fifty specimens — come from Verőcemaros (North Hungary). The locality has not been mentioned in publications yet, it has been referred to merely as *Platanus neptuni* (Ett.) Bůžek–Holý–Kvaček (HABLY 1980). Unfortunately, no further collecting was possible because the exact location of the locality is unknown. The age of the flora is Egerian. The NAGYMAROSY nannoplankton-test indicates NP 25 zone, since it contains also *Zygrablithus bijugatus*, *Helicopontosphaera recta* and *Sphenolithus conicus*. There is a significant transfer from the Eocene and mainly from the Cretaceous. On the basis of general nannoplankton-flora profile NAGYMAROSY assumes NP 25 zone to be probable. All this suggests that the Verőcemaros flora can be classified into the Kovačov Formation which contains significant flora locality also in other places.

The remains have been preserved in clayish sandstone. As they do not contain epidermis, they were classified by means of the conventional methods based on morphology. The Tertiary venation — especially with specimens containing smaller quantities of clay — cannot be seen or only very indistinctly.

## Systematic descriptions

### Lauraceae

**Daphnogene lanceolata** Unger (Plate I, 1, 2, 7, 8, Plate IV, 1–4)

1850 *Daphnogene lanceolata* Unger (ex parte), Gen. et Spec. Plant. Foss.: 424 Socka (Upper Oligocene)

1850 *Daphnogene lanceolata* Unger, Denkschr. k. Akad. Wiss. math.-nat. cl. 2: 167, Taf. 34, Abb. 1–7. Socka (Upper Oligocene)

1873 *Daphnogene ungeri* Heer et Engelhardt, Nov. Acta. Leop. 36: 27, Taf. 5, Abb. 5. Göhren (Middle Oligocene)

1873 *Eucalyptus oceanica* Unger et Engelhardt, ibid.: 29, Taf. 5, Abb. 11. Göhren (Middle Oligocene)

1926 *Loranthophyllum* sp., Menzel, Beitr. Gel, Thüring. 5: 32, Abb. 6. Waltersdorf (Middle Oligocene)

1934 *Daphnogene lanceolata* Unger et Weyland, Abh. Preuss. Geol. L. A. NF 161: 83, Taf. 11, Abb. 6, Taf. 13, Abb. 7, Taf. 14, Abb. 8. Altenrath (Middle Oligocene)

1940 *Daphnogene septimontana* Weyland, Paleontogr. B. 84: 110, Taf. 4, Abb. 3–7. Altenrath (Middle Oligocene)

1950 *Daphnogene septimontana* Weyland, KRAUSEL and WEYLAND, Paleontogr. B. 91: 64, Taf. 14, Abb. 5–8, Textabb. 24. Altenrath (Middle Oligocene)

1950 *Cinnamomophyllum scheuchzeri* (Heer) Krausel et Weyland, Paleontogr. B. 91: 68, Taf. 11, Abb. 7, Taf. 16, Abb. 1–6, Taf. 17, Abb. 1, Abb. 25 (Nr. 6343/1, 6344/1). Regis (Middle Oligocene)

1963 *Cinnamomophyllum scheuchzeri* (Heer) Krausel et Weyland, MAI Jb. Staatl. Mus. Mineral. Geol. Dresden: 71, Taf. 8, Abb. 4–6. Seifhennersdorf (Middle Oligocene)

1963 *Laurophyllum acutimontanum* Mai, ibid.: Taf. 8, Abb. 10, Textfig. 11a–e. Seifhennersdorf (Middle Oligocene)

1964 *Cinnamomophyllum scheuchzeri* (Heer) Krausel et Weyland, WALTHER, Jb. Staatl. Mus. Mineral. Geol. Dresden: 48, Taf. 17, Abb. 1–4. Seifhennersdorf (Lower Oligocene)

1965 *Cinnamomophyllum bitterfeldense* Schneider, Geologie 14, H. 10: 1241, Taf. 4, Bild 11–13, Abb. 5. Bitterfeld (Middle Oligocene)

1976 *Daphnogene lanceolata* Unger, BŮŽEK, HOLÝ and KVAČEK, Sborn. geol. véd. paleont. 18: 100, Taf. 7, Abb. 1–4, Taf. 19, Abb. 3–7. Markvartice (Egerian)

1978 *Daphnogene lanceolata* Unger, MAI and WALTHER, Abh. Staatl. Mus. Mineral. Geol. Dresden: 28: 40, Taf. 2, Abb. 1–23, Taf. 19, Abb. 1–15, Taf. 20, Abb. 1–4. Haselbacher Serie (Middle Oligocene)

Material: No. 79. 1. 1.; 79. 7. 1.; 79. 8. 1.; 79. 9. 2.

Description: Leaves mostly narrow lanceolate, lamina symmetrical or asymmetrical, trinerved. Lamina length 6–8 cm, width 1.7–2.2 cm. Base acute, margin entire, venation acrodromous, suprabasal, imperfect. The species is very frequent in the Tertiary. In Hungary it is especially widespread in the Egerian. In tropical forests today, laurel forests are found below 800 m a.s.l. Their water-need is about 1000–2000 mm at 21–23 °C mean annual temperature. Even if no such tropical climate existed, they must have been thermophilous element of forests of low mountains.

**Daphnogene cinnamomifolia** (Brongiart in Cuvier) Unger (Plate I, 3, Plate IV, 5)

1822 *Phyllites cinnamomifolia* Brongniart in Cuvier, Recherch. sur les oss. foss. 2 Bd. Habichtswald (Lower Miocene)

1850 *Daphnogene cinnamomifolia* Unger, Denkschr. k. Akad. Wiss. math.-nat. Cl. 2: 168, Taf. 39, Abb. 7–9. Socka (Upper Oligocene)

1873 *Cinnamomum rossmässleri* Heer et Engelhardt, Nov. Act. Leop. 36: 26, Taf. 5, Abb. 4, Göhren (Middle Oligocene)

1950 *Cinnamomophyllum polymorphum* (A. Br.) Krausel et Weyland, Paleontogr. B. 91: 70, Taf. 17, Abb. 2–3, Taf. 18, Abb. 1, Abb. 27. Regis II/III. (Middle Oligocene)

1974 *Daphnogene cinnamomifolia* (Brong. in Cuvier) Unger, KVAČEK and WALTHER, Abh. Staatl. Mus. Mineral. Geol. 21: 199, Taf. 1, Abb. 1–2, Taf. 2, Abb. 1–5, Abb. 1–2. Habichtswald (Lower Miocene)

1974 *Daphnogene cinnamomifolia* (Brong. in Cuvier) Unger, KVAČEK and WALTHER, ibid.: 202, Taf. 1, Abb. 4, Taf. 3, Abb. 1–5, Abb. 3. Seifhennersdorf (Lower Miocene)

1974 *Daphnogene cinnamomifolia* (Brong. in Cuvier) Unger, KVAČEK and WALTHER, ibid.: 201, Taf. 1, Abb. 3, Taf. 4, Abb. 1–3. Meissner (Lower Miocene)

1978 *Daphnogene cinnamomifolia* (Brong. in Cuvier) Unger, Mai and Walther, Abh. Staatl. Mus. Mineral. Geol. Dresden: 28: 43, Taf. 2, Abb. 24–25, Taf. 20, Abb. 5–9, Abb. 21, Abb. 1–2. Haselbacher Serie (Middle Oligocene)

Material: No. 79. 18. 1.

Description: Leaves narrow elliptic, lamina asymmetrical, trinerved. Lamina length 8 cm, width 4 cm. Base acute, margin entire, venation acrodromous, suprabasal. Only one specimen of the flora has been found. It is not a very rare specimen in the Tertiary, but common especially in the Oligocene and Miocene.

**Daphnogene bilinica** (Unger) Knobloch et Kvaček (Plate I, 5, Plate IV, 6)

1847 *Ceanothus bilinicus* Unger, Chlor. prot.: 145, Tab. 49, Fig. 9.

1950 *Cinnamomophyllum scheuchzeri* (Heer) Krausel et Weyland, Paleontogr. B. 91 (1–4): 68, Taf. 11, Abb. 7, Taf. 16, Abb. 1–6, Taf. 17, Abb. 1, Taf. 18, Abb. 2–4, Textabb. 25–26.

1963 *Cinnamomophyllum polymorphum* (A. BR.) Krausel et Weyland, Weyland and Kilpper, Paleontogr. B. 113 (5–6): 104, Taf. 25, Abb. 28–29, Textabb. 10.

1964 *Cinnamomophyllum bilinicum* (Unger) Knobloch, Neues Jb. Geol. Pal. Mh.: 601.

1965 *Cinnamomophyllum bitterfeldense* Schneider, Geologie 14 (10): 1241, Taf. 4, Abb. 11–13, Textabb. 5.

1967 *Daphnogene bilinica* (Ung.) Knobloch et Kvaček, Vest. UUG 42 (3): 201.

1971 *Daphnogene bilinica* (Ung.) Knobloch et Kvaček, Kvaček, Sbor. Geol. Věd. R. P. 13: 67, Pl. 2, Abb. 1–4, Pl. 9, Abb. 4–6, Textabb. 14. Kučlin (Middle Oligocene) Kundratice, Markvartice, Knizeci (= Pirksenberg) (Egerian)

1978 *Daphnogene bilinica* (Ung.) Kvaček et Knobloch, Ticleanu and Givulescu, Cour. Forsch. Inst. Senckenberg 30: 140, Taf. 2, Abb. 1–4, 8, 9, Taf. 3, Abb. 6–7. Corus II. Cluj (Upper Egerian)

1979 *Daphnogene bilinica* (Ung.) Kvaček et Knobloch, Hably, Ann. Hist.-nat. Mus. Nat. Hung. 71: 56, Textabb. 1. Baromállás (Tatabánya) (Egerian)

Material: No. 79. 9. 2.; 79. 14. 1. (3 specimen).*

Description: Leaves oblong, lamina asymmetrical, trinerved. Lamina length 2–3 cm, width to 0.5–1.6 cm. Margin entire, base acute, venation acrodromous, suprabasal imperfect. In the flora it is represented only by three specimens: two by very small leaves and a basal-fragment. It is rather widespread in the Tertiary.

### Platanaceae

**Platanus neptuni** (Ettingshausen) Bůžek, Holý et Kvaček (Plate I, 4, 6, 9, 10, 11, Plate II, 1–2, Plate V, 1–6, Plate VI, 1–6, Plate VII, 2–4, Plate VIII, 1)

1866 *Sparganium neptuni* Ettingshausen, Foss. Flora Bilin I.: 31, Taf. 7, Abb. 9–15. Kučlin (Middle Oligocene)

1866 *Sparganium extinctum* Ett., ibid.: 31, Taf. 7, Abb. 8. Kučlin (Middle Oligocene)

1869 *Bombax chorisiaefolium* Ett., Foss. Flora Bilin III.: 11, Taf. 42, Abb. 2, 4, 5. Kučlin (Middle Oligocene)

1869 *Quercus arctocarpites* Ett., ibid.: 63, Taf. 55, Abb. 19. Kučlin (Middle Oligocene)

1869 *Ceratopetalum haeringianum* Ett., ibid.: 6, Taf. 40, Abb. 27–28, Taf. 41, Abb. 4–5. Kučlin (Middle Oligocene)

* The specimen number and the inventory number are different in the case of several imprints in the stone.

1885 *Ceratopetalum cundraticiense* Engelhardt, Nova Acta Leop.: 48, Taf. 11, Abb. 2. Kundratice (Egerian)
1898 *Viburnum oligocenicum* Engelhardt, Abh. dt. nat med. Ver. Lotos 1 (3): 96, Taf. 9, Abb. 61.
1898 *Ampelopsis bohemica* Engelhardt, ibid.: 101, Taf. 10, Abb. 23–26.
1898 *Elaeodendron grandifolium* Engelhardt, ibid.: 107, Taf. 10, Abb. 30.
1898 *Phyllites quercoides* Engelhardt, ibid.: 116, Taf. 11, Abb. 29.
1898 *Phyllites amphirocioides* Engelhardt, ibid.: 116, Taf. 11, Abb. 47, 68, 79.
1898 *Equisetites ettingshauseni* Engelhardt, ibid.: 85, Taf. 9, Abb. 6, 8, 11, 30, 31, 36, 37.
1967 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, Monatsber. Deutsch. Akad. Wiss. Berlin 9 (3): 205, Taf. 1, Abb. 1–6, Taf. 2, Fig. 1–9. Suletice, Markvartice, Kundratice (Egerian), Kučlin (Middle Oligocene)
1971 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, KVAČEK, Paleontogr. B. 3: 435, Pl. 56, Fig. 1, 5, 6, Pl. 56, Fig. 1–3.
1973 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, KNOBLOCH, "Der Aufschluss" 24 (7–8): 281, Abb. 1, 2, 4. Bois d'Asson (Upper Oligocene)
1975 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, KNOBLOCH et al., Biozonal. Divis. Upper Tertiary Bas. East. Alps. West. Carpath. Geol. Survey Prague 88, 89, 91. Markvartice, Bechlejovice, Kundratice, Knižeci, Krumvíř, Ždanice (Egerian), Cheb Basin, borehole (Karpatian)
1978 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, KVAČEK and WALTHER, Cour. Forsch. Inst. Senckenberg 30: 81, Textabb. 5. Markvartice (Egerian)
1978 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, BŮŽEK, KVAČEK and WALTHER, Vestnik UUG 53: Pl. 3, Fig. 6. Kundratice (Egerian)
1979 *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček, HABLY, Ann. Hist.-nat. Mus. Nat. Hung. 71: Pl. 8, Fig. 1–5, Pl. 9, Fig. 2, 3, 5, 6, Pl. 10, Fig. 1–5, Pl. 11, Fig. 1–3. Budapest, Tard Clay Formation (Kiscellian = Lower Oligocene)

Material: No. 79. 4. 1.; 79. 5. 2.; 79. 10. 1.; 79. 11. 1.; 79. 12. 2.; 79. 14. 1.; 79. 15. 1.; 79. 16. 2. (17 specimen)

Description: Medium and large leaves, 1.9–3.3 cm wide and 6–12 cm long. Margin entire at base, from one third of lamina upwards indented. Venation camptodromous, brochidodromous. Beside the leaf remains two inflorescence have been found in the Verőcemaros flora. One is 0.9 cm long together with stalk, the inflorescence is 0.2 cm in diameter. The other is slightly larger, with a length of 1.2 cm and a diameter of 0.4 cm.

### Aceraceae

**Acer** sp. (Plate VIII, 5–6)

Material: No. 79. 12. 2. (2 specimen)

Description: The flora did not yield any recognizable Acer leaf-remains, only two pieces of half-fruit impression, 1.7 and 2.0 cm respectively.

### Tiliaceae

**Tilia** sp. (Plate VIII, 4)

Material: No. 79. 17. 1.

Description: The flora yielded an elongated leaflike growth, with entire margin, length 5–8 cm, width 1.1 cm. In the middle the imprint of a spherical body with 0.6 cm diameter can be observed. It is probably the bract-leaf of Tilia with an attached fruit.

### Ulmaceae

**Zelkova zelkovaefolia** (Ung. 1843) Bůžek et Kotlaba (Plate II, 9, Plate VII, 3)
1843 *Ulmus zelkovaefolia* Unger pl. 24.
1851 *Zelkova ungeri* (Ett.) Kováts
1963 *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, Kotlaba p. 59.
1971 *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, Bůžek p. 58.
1976 *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba, Knobloch and Kvaček p. 49.
Material: No. 79. 5. 2.
Description: Only one specimen of this species has been found in the flora. This is an apical fragment. Apex acute, venation simple craspedodromous, margin indented. Secundary venation ended at the tooth apex. Zelkova is very frequent in the Hungarian Miocene. It is a dominant element in some localities of the Sarmatian stage. In the Hungarian Upper Oligocene it is rare, and unknown in the Lower Oligocene.

**Ulmus** cf. **fischeri** Heer (Plate II, 5, Plate VII, 1)
1856 *Ulmus Fischeri* Heer, Heer, Flora tert. Helv. II. 57, Taf. 79, Abb. 1–3.
1885 *Ulmus Fischeri* Heer, Engelhardt, Nova Acta Leop. Ak. Nat. 48: 322, Taf. 11, Abb. 31.
1969 *Ulmus* cf. *fischeri* Heer, Knobloch, Tert. Flor. Mähren: 106, Taf. 52, Abb. 10.
1976 *Ulmus* cf. *fischeri* Heer, Bůžek, Holy et Kvaček, Journ. Geol. Sci. palaeontology 18: 95, Pl. VI. Fig. 7–8.
Material: No. 79. 14. 1.
Description: The leaf is symmetrical and 8.5 cm long, the width of one half of the lamina is 2.2 cm. From the main vein a not fully perfect secondary venation branches out, with indented endings, indicating that it is craspedodromous. Margin indented teeth compound with smaller units at each base. The species is described mainly from the Czech Egerian and the Swiss Tertiary.

### Myricaceae

**Myrica banksiaefolia** Unger (Plate II, 3, 4, 6, 7, 11, Plate VIII, 2–3, Plate IX, 1–3)
1850 *Myrica banksiaefolia* Unger, Gen. et spec. Plant.: 395.
1856 *Dryandroides banksiaefolia* Heer, Flora Tert. Helv. II.: 102, Taf. 100, Abb. 3–10.
1865 *Myrica* (*Dryandroides*) *banksiaefolia* Ung., Saporta, Ann. Sci. Nat. Bot. 5, 4: 103.
Material: No. 79. 5. 2.; 79. 8. 2.; 79. 14. 1.; 79. 18. 1. (5 specimen)
Description: Fragmentary remains rich in formal variety characteristic of Myrica leaves: narrow, long, slightly asymmetrical. Entire margin at the base, indented at the upper part. Venation craspedodromous or semicraspedodromous. Base and apex acute, base lanceolate.

### Palmae

cf. **Calamus noszkyi** Jablonszky (Plate XII, 2, 3, 5)
1914 *Calamus Noszkyi* Jablonszky, Magy. Kir. Földt. Int. Évk. 22 (4): 236, Taf. I, Abb. 1–3.
1959 *Calamus noszkyi* Jabl., Rásky, Journ. Paleont. 33 (3): 454.
Material: No. 79. 2. 1.; 79. 4. 1.; 79. 9. 2.; 79. 16. 2.
Description: A few small palm-fragments have been found belonging probably to Calamus noszkyi Jabl. known from Ipolytarnóc. They are not well preserved to show the awns of the leaflets. The vein in the middle is occasionally distinct; the leaf is 1.9–2.3 cm long. The species originates from Ipolytarnóc, its age is Ottnangian. The palm indicates by all means, warm, moist, wet climate.

### Plantae incertae sedis

**Debeya hungarica** sp. n. (Plate II, 8, 10, Plate III, 1–3, 5–8, Plate IX, 4, 5, Plate X, 1–4, Plate XI, 1–4, Plate XII, 1)

Holotypus: No. 79. 5. 2. Pl. III. Figs 1–2; Pl. X. Figs 1–2.
Derivatio nominis: from Hungary
Locus typicus: Verőcemaros (North Hungary)
Stratum typicum: stage Egerian (Upper Oligocene), Kovačov Formation, NP 25 nannoplankton zone
Material: No. 79. 3. 1.; 79. 5. 2.; 79. 6. 1.; 79. 7. 1.; 79. 8. 1.; 79. 9. 2.; 79. 13. 1.; 79. 16. 2.; 79. 17. 1. (12 specimen)

Description: The leaves consist of three leaflets springing from one centre. They have no individual leaflet-petiole, but they are not mutually intergrown. Almost all the specimens are fragmentary, but their large number allows reconstruction. Their original measurements range from 3 to 15 cm. On the basis of morphological features they are divided into two groups.

1. Large leaves consisting always of three leaflets, length 12–15 cm, width 2–2.5 cm. The petiole is 1.6–1.7 cm long, generally thick with widening ends. The margin of the leaflets is frequently fragmentary, they are well preserved and whole. The main veins are strong. The camptodrome-brochidodrome character of the secondary venation can be rarely seen on account of poor preservation, so it often appears to be reticulodromous. The base of the leaflets is slightly asymmetrical. The mid-leaflet is not bigger than the two flanking ones.

2. The other part of the leaves is small. It contains also entire specimens, but none of them has a petiole. Like the previous type, these too, have three leaflets. The leaflets are equal, the middle leaflet is not more developed than the side ones. They are both oblong, the apex and the basis are acute. The basis is but slightly asymmetrical. The venation is campto-dromous; in some cases it shows brochidodromous characteristics, in other cases it looks merely reticulodrome. In my opinion the two types belong to the same species, differences are due to ecological reasons only. The larger leaves are probably shade leaves, while the small ones are sun leaves.

No such find has been known so far from Hungary. In paleobotanical literature references to such remains are often made. The characteristic shape of the leaf makes it relatively easy to establish the relationship, but the problem of its taxonomic classification has not been solved. I classify the species into the Debeya form-genus, which, so far, has been found only in Paleocene and Eocene sediments. The Verőcemaros species is much younger than that, dating from the Upper Oligocene. SEWARD and CONWAY (1935) mention similar remains from Greenland (Kingigtok), under the name *Dicotylophyllum bellum*. The rest of similar remains are mentioned under *Dewalquea*, which, on the basis of KNOBLOCH's (1964) revision has to be called *Debeya*. The new species can be well isolated from those having indented margin. It differs significantly from *Debeya gelindenensis* (Sap. et Mar.) Knobl. with entire margin insomuch as in that not only three, but more leaflets grow from the petiole, often not from the same centre, but from small petioles arising

on the petiole. The *Debeya* genus is widespread in the Cretaceous and the Paleogene; ranging from Greenland to Bulgaria, from Belgium to Kazakhstan, though not too frequent (Makulbekov 1977).

From morphological point of view the species in Hungary is nearest to *Dicotylophyllum bellum*. This too, has leaflets with entire margin. The leaf consists invariably of three leaflets of oblong shape. The venation, however, does not show brochidodrome characteristics, although this may be due to poor preservation. A considerable difference however is that *Dicotylophyllum*'s petiole is so thick that the bases of the leaflets literally sink into it. *Debeya hungarica* sp. n. never shows this feature. Mention must be made also of *Picrodendron* genus possessing similar leaf characteristics; Koch (1972) relates this to *Dicotylophyllum* pointing out that the two leaves are entirely similar. Since the leaflets of *Picrodendron* possess petiole of quite considerable length, *Docotylophyllum bellum* cannot be identified with the *Debeya* genus. Similar considerations led us to disregarding *Acer henryitis* in spite of the fact that the locality contains *Acer fruits*. Of recent species the *Rubus henryi* var. *bambusarum* Hemsl. et Rehd. shows remarkable similarity with the indented *Debeya* species. This is a 6 metre high shrub in Central China. The three leaflets of which grow from one point are oblong, with brochidodromous venation and indented margin. It is regrettable that the *Debeya* remains sofar recovered, — including those from Verőcemaros —, do not contain epidermis, which could probably render valuable information in solving the problem.

The ecological and climatological demands of *Debeya hungarica* sp. n. can be deduced from the Oligocene climate Hungary. The elements of the Verőcemaros flora are relatively thermophilous, mainly paleotropical elements, the most characteristic ones are *Platanus neptuni* and the Lauraceae family. The flora contains a smaller quantity of Arctotertiary elements than in the other Egerian floras in Hungary. It seems that the survival of a thermophilous flora was facilitated by microclimatological or other factors. This supports the possibility of the existence of a *Debeya* as an Upper Oligocene relic. As its main period of existence is that of the Cretaceous and the Paleogene, it had its heyday under tropical–subtropical circumstances.

## Ecological, paleoclimatological evaluation

The flora of Verőcemaros by its species composition itself, shows thermophilous characteristics which is unusual in the Hungarian Egerian. *Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček is present in larges number, which according to Knobloch (1973) is bound with expressedly warm periods. This is supported by the presence of palms, of laurel and *Myrica*. If we calculate by percentage the proportion of Arctotertiary and Paleotropical elements, we

find that 60% of the species are paleotropical, while considering specimen number as well, the Paleotropical elements constitue 90%. This is a rather unusual proportion in the Egerian floras in Hungary, since our Egerian is characterized by the preponderance of an Arctotertiary flora. Even the Arctotertiary species are not expressedly cold-suffer. They are all riverside plants, so their climatological value is rather uncertain. *Acer*, *Ulmus* can be found under rather wide climatological conditions along riversides. This flora offers a fairly adequate explanation for the presence in the Egerian of a genus species characteristic of the Upper Cretaceous, Paleocene. The survival of *Debeya hungarica* sp. n. is due to microclimatological factors. The climate must have been more wet, which is indicated partly by the presence of palms, and partly by the size of *Platanus neptuni* (HABLY 1980). The presence of extensive swamp-forests is excluded: both *Taxodium* and *Sequoia* — so characteristic of the Egerian in Hungary — are absent. It is also remarkable that the flora contains neither ferns nor gymnosperms. The majority of the species, consequently, lived far from riversides; *Myrica* the only mark indicating bog, but this can occur at riversides as well.

On the basis of the principle of actualism deductions can be made concerning the morphology of the surroundings as well. In the present riverside tropical forests riverflats, riverside plants live right on the banks, and laurel decorates the slopes up to a height of 800 metres. The members of the Myrtaceae forests next to it are already absent from the Verőcemaros flora. Similarly, *Platanus neptuni* must have lived on low mountains, rather on hillsides. This indicates that the Verőcemaros flora belonged to the vegetation of a hilly riverside area. Laurel forests today live in the tropical belt under climatological conditions characterised by 1000–2000 mm rainfall per year, and 21–23 °C mean annual temperature. In summer the characteristic temperature is 30 °C. These conditions seem to be realistic in the case of the Verőcemaros flora. 30 °C for summer mean temperature is not extremely high, but the 21–23 °C mean annual temperature indicates that an even warm temperature prevails all the year round. These conditions favour the development of a thermophilous flora and in it the survival of relics. No xerophilous characteristics are presented by the flora. Measurements made on *Platanus neptuni* — a comparison with *Platanus neptuni* specimens in the Tard Clay Formation (Kiscellian, Lower Oligocene) flora demonstrated that the size of the plants and of the lamina is considerably larger in the Verőcemaros flora.

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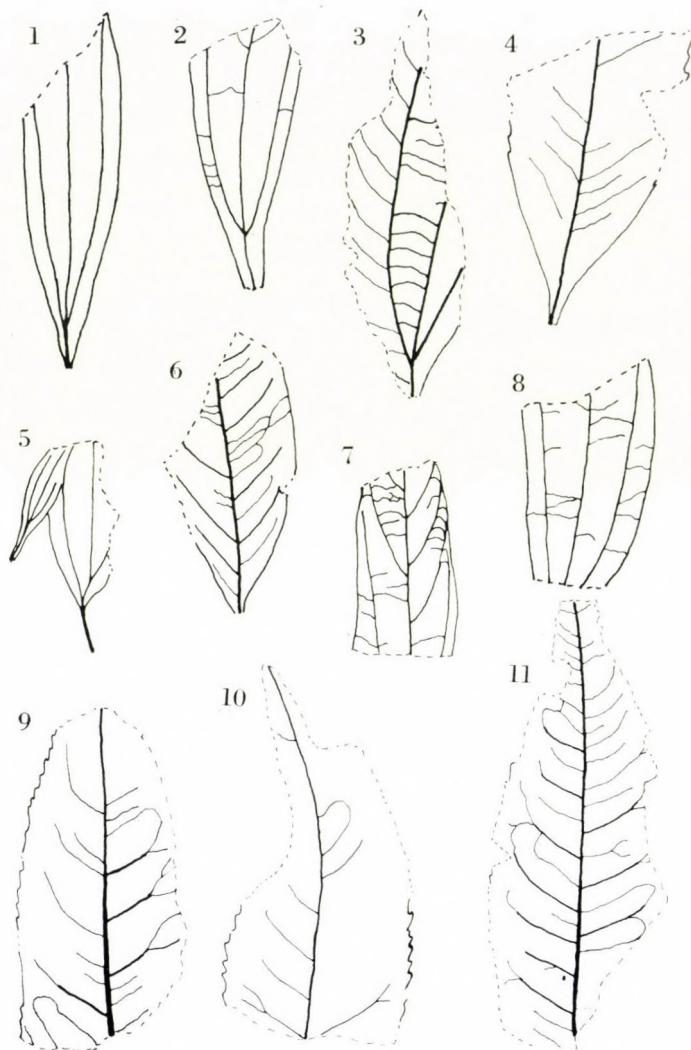
**Plate I**

*Daphnogene lanceolata* Unger — 1. 79. 1. 1. ×0.75 — 2. 79. 7. 1. ×0.75 — 7. 79. 9. 2. ×0.75 — 8. 79. 8. 1. ×0.75
*Daphnogene cinnamomifolia* (Brong. in Cuv.) Ung. — 3. 79. 18. 1. ×0.75
*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 4. 79. 16. 1. ×0.75 — 6. 79. 14. 1. ×0.75 — 9. 79. 5. 2. ×0.75 — 10. 79. 12. 2. ×0.75 — 11. 79. 16. 1. ×0.75
*Daphnogene bilinica* (Ung.) Knobloch et Kvaček — 5. 79. 14. 1. ×0.75
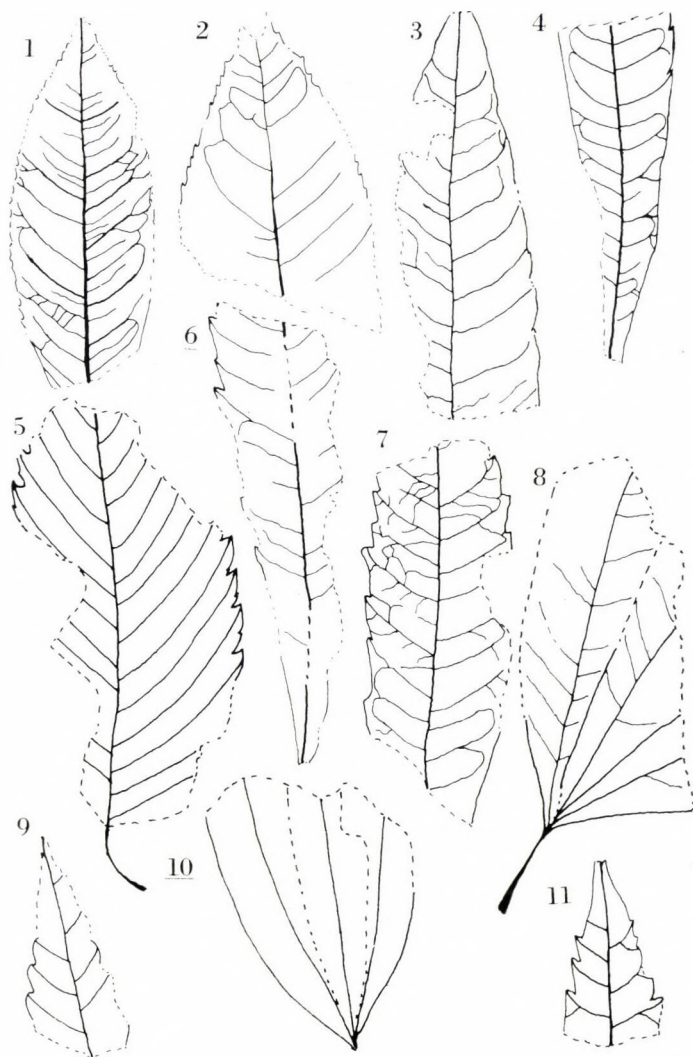
**Plate II**

*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 1. 79. 10. 1. ×0.75 — 2. 79. 9. 2. ×0.75
*Myrica banksiaefolia* Unger — 3. 79. 5. 2. ×0.75 — 4. 79. 14. 1. ×0.75 — 6. 79. 18. 1. ×0.75 — 7. 79. 8. 1. ×0.75 — 11. 79. 14. 1. ×0.75
*Ulmus* cf. *fischeri* Heer — 5. 79. 14. 1. ×0.75
*Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba — 9. 79. 5. 2. ×0.75
*Debeya hungarica* n. sp. — 8. 79. 13. 1. ×0.75 — 10. 79. 5. 2. ×0.75
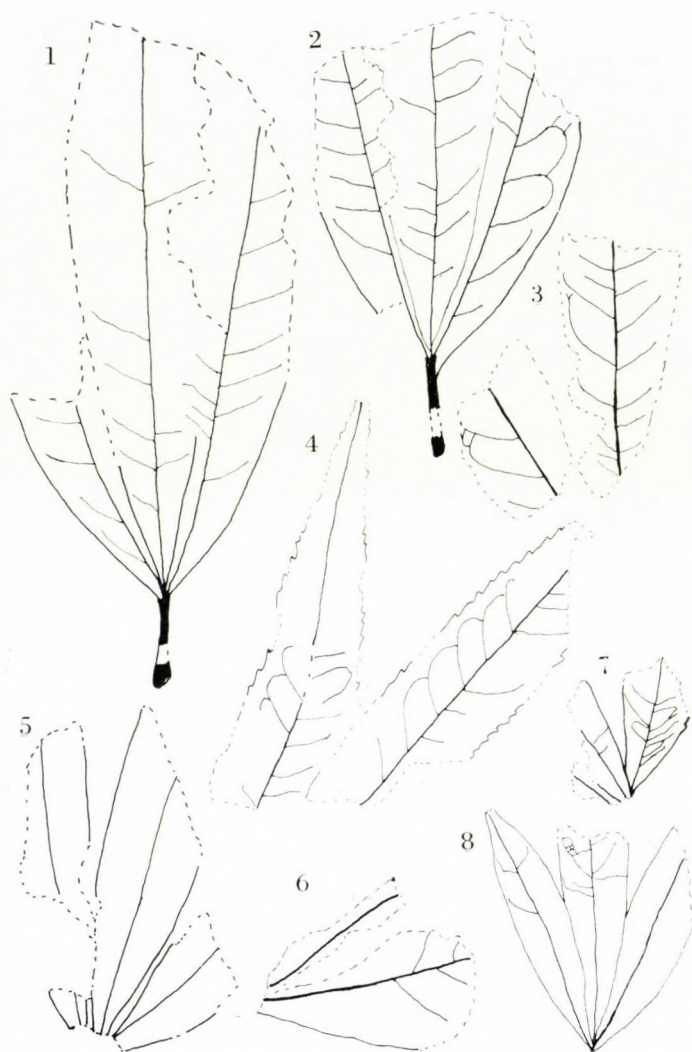
**Plate III**

*Debeya hungarica* n. sp. — 1. 79. 5. 2. ×0.75 holotypus — 2.79. 5. 2. ×0.75 holotypus — 3. 79. 6. 1. ×0.75 — 5. 79. 9. 2. ×0.75 — 6. 79. 7. 1. ×0.75 — 7. 79. 8. 1. ×0.75 — 8. 79. 16. 2. ×0.75
*Plantae incertae sedis* — 4. 79. 12. 1. ×0.75

**Plate IV**

*Daphnogene lanceolata* Ung. — 1. 79. 1. 1. ×1.2 — 2. 79. 7. 1. ×1.2 — 3. 79. 9. 2. ×1.5 — 4. 79. 8. 1. ×1.2
*Daphnogene cinnamomifolia* (Brong. in Cuv.) Ung. — 5. 79. 18. 1. ×1.2
*Daphnogene bilinica* (Ung.) Knobloch et Kvaček — 6. 79. 14. 1. ×1.5

**Plate V**

*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 1. 79. 10. 1. ×1.2 — 2. 79. 4. 1. ×1.2 — 3. 79. 14. 1. ×1.2 — 4. 79. 12. 2. ×2.2 — 5. 79. 14. 1. ×1.2 — 6. 79. 9. 2. ×1.5
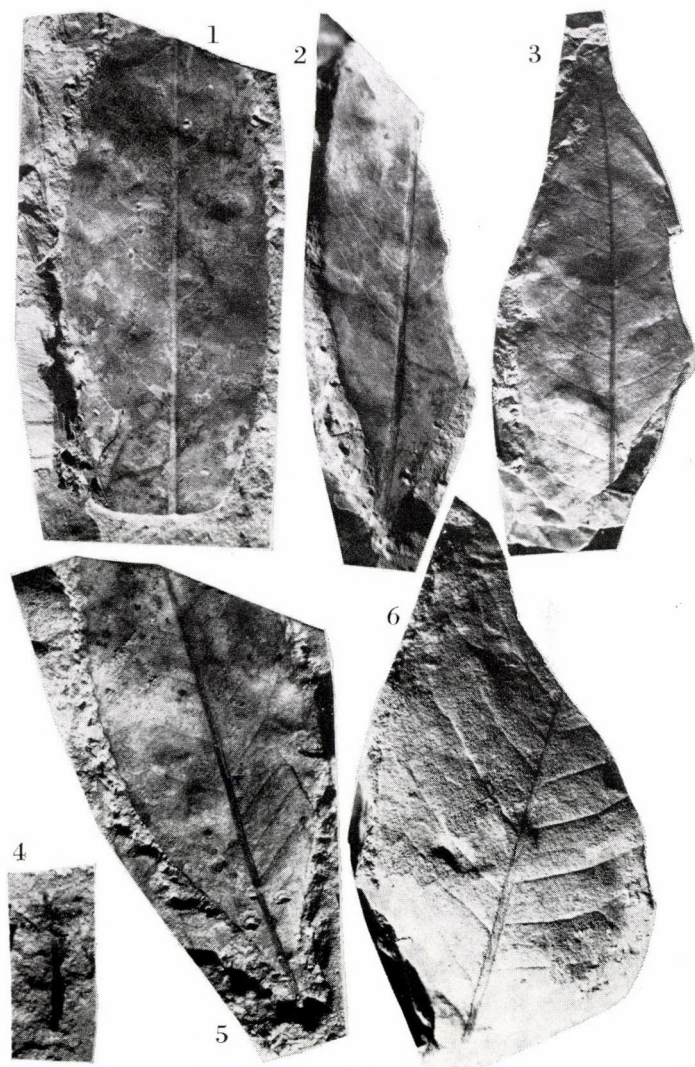
**Plate VI**

*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 1. 79. 12. 1. ×1.2 — 2. 79. 12. 1. ×1.2 — 3. 79. 16. 1. ×0.75 — 4. 79. 12. 2. ×2.2 — 5. 79. 9. 2. ×1.2 — 6. 79. 11. 1. ×1.2

**Plate VII**

*Ulmus* cf. *fischeri* Heer — 1. 79. 14. 1. ×1.2
*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 2. 79. 5. 2. ×1.2 — 4. 79. 9. 2. ×1.2
*Zelkova zelkovaefolia* (Ung.) Bůžek et Kotlaba — 3. 79. 5. 2. ×1.5

**Plate VIII**

*Platanus neptuni* (Ett.) Bůžek, Holý et Kvaček — 1. 79. 16. 1. ×1.2
*Myrica banksiaefolia* Unger — 2. 79. 14. 1. ×1.5 — 3. 79. 18. 1. ×1.2
*Tilia* sp. — 4. 79. 17. 1. ×1.2
*Acer* sp. — 5. 79. 12. 2. ×3 — 6. 79. 12. 2. ×3

**Plate IX**

*Myrica banksiaefolia* Unger — 1. 79. 5. 2. ×1.2 — 2. 79. 8. 1. ×1.2 — 3. 79. 14. 1. ×1.2
*Plantae incertae sedis* — 4. 79. 3. 1. ×1.2
*Debeya hungarica* n. sp. — 5. 79. 16. 1. ×1.2

**Plate X**

*Debeya hungarica* n. sp. — 1. 79. 5. 2. ×0.75 holotypus — 2. 79. 5. 2. ×0.75 holotypus — 3. 79. 9. 2. ×0.75 — 4. 79. 5. 2. ×1.2

**Plate XI**

*Debeya hungarica* n. sp. — 1. 79. 13. 1. ×1.2 — 2. 79. 8. 1. ×1.5 — 3. 79. 6. 1. ×1.2 — 4. 79. 8. 1. ×1.5
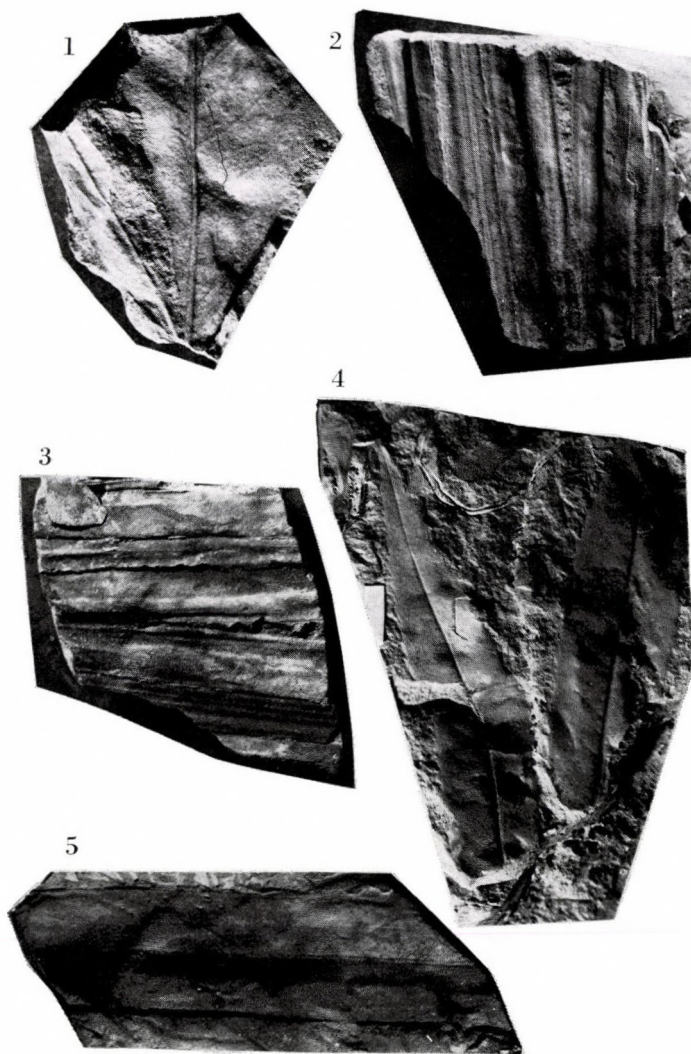
**Plate XII**

*Debeya hungarica* n. sp. — 1. 79. 7. 1. ×1.2
cf. *Calamus noszkyi* Jabl. — 2. 79. 2. 1. ×0.75 — 3. 79. 4. 1. ×0.75 — 5. 79. 9. 2. ×0.75
*Plantae incertae sedis* — 4. 79. 12. 2. ×0.75

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# ASPECTS AND TYPES OF COMPETITION BETWEEN LICHEN SPECIES IN EPIPHYTIC COMMUNITIES

T. Kiss

SAVARIA MUSEUM DEPARTMENT OF NATURAL SCIENCE, SZOMBATHELY, HUNGARY

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The aspects and the types of competition between lichen species in epiphytic communities have been investigated.

For this a special terminology was worked out on the types of contacts between foliaceus-foliaceus, foliaceus-crustose, foliaceus-fruticose and fruticose-fruticose species.

The results indicate that the competition between colonies is very strong, above all on the small surfaces, in the optimal and terminal phases of succession.

It was found that the histological and morphological construction of thalli play a very important role in this aspect of the competition. This was most obvious in the types of contacts between laciniate foliose and fruticose species. The strap-shaped and thread-like fruticose species have supporting tissues which withstand the lateral pressure. Thus these colonies always vertically overgrow other species which belong to other life forms.

## Introduction

An assessment of the demographic processes of competition is usually based on the numerical changes of individuals per unit time. The study of the competition in lichen communities is still at an initial stage. Thus there are not enough quantitative data available about the numerical changes of populations and its relations to the processes of competition.

Only the physical appearance of competition between colonies has been dealt with. The different types of competition have been studied only in saxicolous lichen communities. Types of contacts between crustose and squamulose species have been extensively studied (Malinowski 1972, Degelius 1940, Topham 1977, Hawksworth and Chater 1979, Pentecost 1980). However, no research has yet been done on the aspects and types of competition in epiphytic communities.

In this study the author's observations of epiphytic communities will be described and various types and aspects of competition between foliaceus-foliaceus, foliaceus-crustose, foliaceus-fruticose and fruticose-fruticose species will be discussed.

## Methods

Field observations were made of epiphytic communities in western Hungary, in a vineyard and several forests. The examinations were carried out on the trunks of *Picea abies, Pinus silvestris, Quercus robur* and on vine-stocks and vine branches.

The list of examined lichen species and their life forms (the abbreviations of life forms, after Gallé 1976–77):

Ex *Bacidia luteola* (Schrad.) Mudd.
Ex *Diplotomma alboatra* (Hoffm.) Br. et Rostr.
Ra *Evernia prunastri* (L.) Ach.
Pa *Hypogymnia physodes* (L.) Nyl.
Pa *Parmelia exasperatula* Nyl.

Pa *Parmelia subargentifera* Nyl. var. *conspurcata* (Sch.) Nyl.
Pa *Parmelia sulcata* Tayl.
Ra *Pseudevernia furfuracea* (L.) Zopf.
Us *Usnea hirta* (L.) Wigg. var. *minutissima* (Mer.) Hillm.

On the basis of terminology of HAWKSWORTH and CHATER (1979), and PENTECOST (1980), I have designed also a special terminology for epiphytic lichens (Tables 1–3).

**Table 1**

*Overgrowth terminology*

| Expression | Description |
|---|---|
| A m B | marginal overgrowth: A overgrows B |
| B m A | B marginally overgrows A |
| A B | A overgrows B |
| B A | B overgrows A |
| A m B m C | several marginal overgrowths: A marginally overgrows B, B marginally overgrows C |
| A B C | several overgrowths: A overgrows B, B overgrows C |
| A . B | A overgrows epiphytically upon B |
| B . A | B overgrows epiphytically upon A |
| A $\vee$ B | A vertically overgrows B |
| B $\vee$ A | B vertically overgrows A |
| A $\vee$ $\underline{B}$ | A vertically overgrows the lower part of B |
| B $\vee$ $\underline{A}$ | B vertically overgrows the lower part of A |
| A $\vee$ B $\vee$ C | several vertical overgrowths: A overgrows B, B overgrows C |

**Table 2**

*Terminology of line contacts*

| Expression | Description |
|---|---|
| $\underline{A}$ m $\underline{B}$ | line contact with lower marginal surface |
| $\underline{A}$ m $\overline{B}$ | the lower surface of A in contact with upper surface of A |
| $\underline{B}$ m $\overline{A}$ | the lower surface of B contacts the upper surface of A |
| $\overline{A}$ m $\overline{B}$ | the upper surface of A contacts the upper surface of B |
| $\underline{A}$ m $\underline{B}$ m $\underline{C}$ | |
| $\underline{A}$ m $\overline{B}$ m $\underline{C}$ | several types of line contacts |
| $\overline{A}$ m $\overline{B}$ m $\overline{C}$ | |
| A ‖ B | "truce" condition: marginal growth cases |
| A ‖ B ‖ C | several "truce" conditions |

**Table 3**

*Terminology of window contacts*

| Expression | Description |
|---|---|
| $A \wedge B(W)$ | A overgrows in a window of B |
| $B \wedge A(W)$ | B overgrows in a window of A |
| $2A \wedge B(W)$ | two colonies of A overgrow in a window of B |
| $2B \wedge A(W)$ | two colonies of B overgrow in a window of A |

## Classification of overgrowth types and line contacts

This classification contains the types of contacts between foliaceus-foliaceus, foliaceus-crustose, foliaceus-fruticose and fruticose-fruticose lichens.

### A. Overgrowth contacts

A.1. *Marginal overgrowth*: The colony overgrows the central part of the other thallus.
A.2. *Overgrowth*: The colony overgrows further than the central part of the other thallus.
A.3. *Several marginal overgrowths*: Marginal overgrowths between more than two colonies.
A.4. *Several overgrowths*: Overgrowth contacts between more than two colonies.

### B. Line contacts

B.1. The thalli contact their lower marginal surfaces.
B.2. The lower part of one of the colony contacts the margin of the other colony, but it does not grow over it.
B.3. The colonies contact the upper surfaces.
B.4. The colonies contact on their margins but they do not grow onto each other. In this case the marginal growth is stopped ("truce" condition).

### C. Vertical overgrowth contacts

C.1. The fruticose species overgrows the foliaceus.
C.2. One fruticose overgrows another.
C.3. The foliaceus species overgrows the lower part of the fruticose.
C.4. *Several vertical overgrowths*: vertical overgrowth between more than two colonies.

### D. Window contacts

The central regions of older thalli disintegrate and on these surfaces the process of recolonization begins.

D.1. Window contacts between the same species.
D.2. Window contacts between different species.
D.3. More than two juvenile colonies grow into the recolonized part or parts of the older thalli.
D.4. Window contacts between species which belong to different live forms.
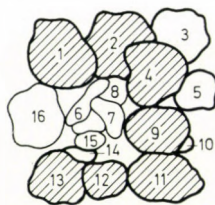
*Fig. 1.* Inter- and intraspecific competition between juvenile colonies of *Hypogymnia physodes* and *Parmelia sulcata*. Substratum: vine-stock, on 16 cm² surface. The types of contacts: A = *Hypogymnia physodes* (shaded), B = *Parmelia sulcata* (unshaded). A ∥ A; A $\widehat{m}$ A; B ∥ B; B $\widehat{m}$ B; B ∧ B; A ∥ B; A $\widehat{m}$ B; A ∧ B

These survey methods are suitable for interpreting the contacts and competition between only two or three colonies.

We can describe the multiple relationships between colonies on supraindividual levels only by using the matrix-formula. This new method is represented by the following example.

Figure 1 shows the inter- and intraspecific competition between juvenile colonies of *Parmelia sulcata* and *Hypogymnia physodes*, on vine-stocks, on 16 cm² surface. The outline of colonies was drawn on tracing paper. The drawing of the thalli was copied from tracing paper to graph paper. With the use of graph paper we can measure the area of the colonies and populations in mm². The interpretation of the contacts using the previously defined terminology can be seen in Fig. 1.

**Table 4**

*The matrix-formula, on the example of Hypogymnia physodes and Parmelia sulcata (for explanation see text)*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 2 | 01 | A | 10 | 01 | 00 | 00 | 00 | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 3 | 00 | 01 | B | 01 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 4 | 00 | 10 | 10 | A | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 5 | 00 | 00 | 00 | 01 | B | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 6 | 00 | 00 | 00 | 00 | 00 | B | 01 | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 7 | 00 | 00 | 00 | 00 | 00 | 10 | B | 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| 8 | 00 | 01 | 00 | 00 | 00 | 01 | 01 | B | 00 | 00 | 00 | 00 | 00 | 00 | 01 | 00 |
| 9 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | A | 10 | 10 | 00 | 00 | 00 | 00 | 00 |
| 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 01 | B | 00 | 00 | 00 | 00 | 00 | 00 |
| 11 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 01 | 00 | A | 00 | 00 | 00 | 00 | 00 |
| 12 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | A | 10 | 00 | 00 | 00 |
| 13 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 01 | A | 10 | 00 | 00 |
| 14 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 01 | B | 00 | 00 |
| 15 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 10 | 00 | 00 | 00 | 00 | 00 | 10 | B | 00 |
| 16 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | B |

The matrix-formula expresses the inter- and intraspecific competitions as well. This is a simple method for examining the features of competition in lichen communities.

To prepare the matrix table we have to number each colony. The symbols of the species are found on the mean diagonal.

The matrix-formula in our example is shown in Table 4.

The 0 reports those colonies that we can find under one or more thallus. The 1 reports those colonies which overgrow them.

The (00) is the absence of contacts.

We can read from the matrix-formula also the intra- and interspecific contacts, because the symbols of species are on the mean diagonal. Under this explanation the matrix is asymmetrical.

This method represents the starting point of the further statistical analysis. When we have enough data about the types of relations between species and populations, we will know the structure of the lichen communities and its changes, too.

## Results

### *I. Interspecific and intraspecific competition between foliaceus and foliaceus species*

#### I.1. Hypogymnia physodes — Parmelia sulcata

These species often grow together. They have a similar growth form but their lobes differ in morphology. HALE (1973: 7), has written: *Hypogymnia physodes*, "... is a well-established segregate of *Parmelia* with hollow lobes and no rizines".

The observations were made of the vine-stocks, vine branches and oak trees. The most dominant species found on these plants' surfaces was *Hypogymnia physodes* (Table 5).

The most frequent overgrowth contacts were: B $\widehat{m}$ A and A $\widehat{m}$ B.

In this case only one of the species, *Parmelia sulcata*, has rhizine. JAHNS (1973: 18) has written about the attachment of thalli to a substrate. "When the tip of the rhizines", of the Parmeliaceae-type, "reaches the substrate the growing hypae spread and form a disc-like holdfast attaching the lichen to the substrate. In this disc the hyphae and particles of the substrate are glued together." It is very interesting to observe the contacts between rhizine of *Parmelia sulcata* and the upper surface of *Hypogymnia physodes*. *Parmelia sulcata* has rhizine only to the marginal part of its lobes. The rhizines are smaller and more rare on the end of lobes so this species is able to marginally overgrow *Hypogymnia physodes*. The

**Table 5**

*The types of overgrowth, line and window contacts*

| Overgrowth contacts | Line contacts | Window contacts |
|---|---|---|
| A $\widehat{m}$ B | $\underline{A}$ m $\underline{\underline{B}}$ | A ∧ B(W) |
| B $\widehat{m}$ A | $\underline{A}$ m B | B ∧ A(W) |
| | A ‖ B | |

A = *Hypogymnia physodes* B = *Parmelia sulcata*

rhizine of *Parmelia sulcata* contact the upper surface of *Hypogymnia physodes* but do not attach to it.

Both species have a similar "epicortex" (HAWKSWORTH 1969) above the cortical hypae. They have a "non-pored epicortex" (HALE 1973). This is one of the types of epicortex that is less open than the "pored epicortex". According to my research, these pores should play a very important role in these types of contacts; for example, between *Parmelia* species which have a pored epicortex.

### I.2. Hypogymnia physodes — Hypogymnia physodes

In most cases the lower surfaces of the thalli were in contact with each other. The marginal parts of the lobes did not stick to the substratum. They were usually recurved (Fig. **2**) (Table 6).

On the smaller surfaces of the vine-stocks and branches were observed the several marginal overgrowths. Figure 3a shows the window contacts.
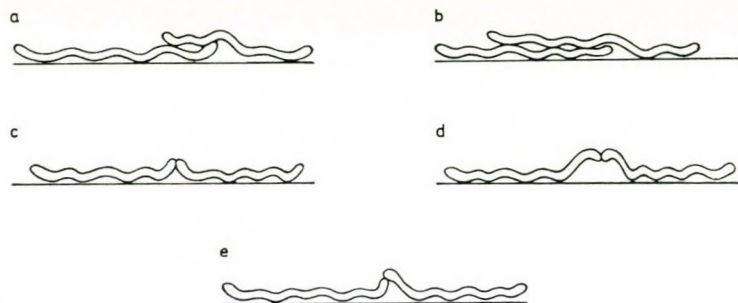
*Fig. 2.* Diagramatic vertical sections showing the types of intraspecific contacts of *Hypogymnia physodes.* a) $A \widehat{m} A$, b) $A \wedge A$, c) $\underline{A}\ m\ \underline{A}$, d) $\overline{A}\ m\ \overline{A}$, e) $\underline{A}\ m\ \overline{A}$

**Table 6**

*Intraspecific contacts between species*

| Overgrowth contacts | Line contacts | Window contacts |
|---|---|---|
| $A\ \widehat{m}\ A$ | $\underline{A}\ m\ \underline{A}$ | $A \wedge A(W)$ |
| $A\ \widehat{m}\ A\ \widehat{m}\ A$ | $\overline{A}\ m\ \overline{A}$ | |
| | $\underline{A}\ m\ \overline{A}$ | |
| | $A \parallel A$ | |

### I.3. Parmelia sulcata — Parmelia sulcata

Overgrowth contacts are observable also between juvenile colonies. The type of line contact: $\underline{B}\ m\ \underline{B}$, is the initial phase of overgrowth contact (Table 7). The several marginal overgrowths and the several overgrowths are typical between juvenile colonies. In many cases the rhizine broke through the upper cortex into the layer of hyphae. On the end of the rhizine disc-like fragments which attach the colony to the other thallus were observable. The question
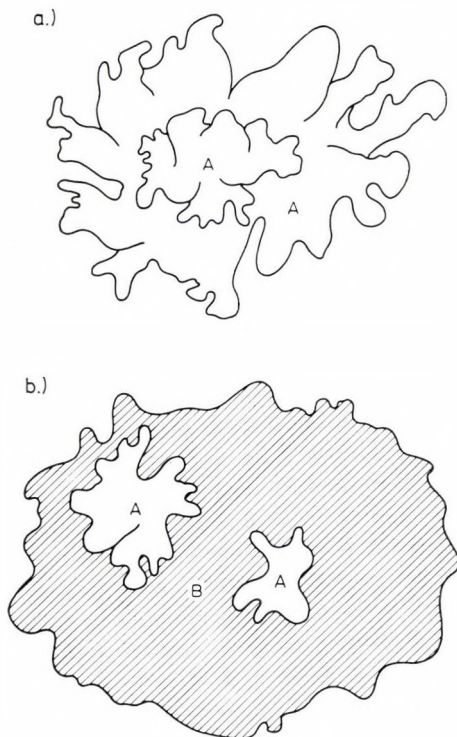
*Fig. 3a.* A juvenile colony of *Hypogymnia physodes* overgrow in a "window" of the same older species

*Fig. 3b.* Window contacts between *Hypogymnia physodes* and *Parmelia subargentifera* var. *conspurcata.* Two juvenile colonies of *Hypogymnia physodes* overgrow in the recolonized parts of *P. subargentifera* var. *conspurcata*

is: how can the rhizine get into the other colony through the cortex ? This is an anatomical and histological problem.

Some known vegetative structures allow the rhizine to penetrate more easily. The aeration pores for example, such as cyphelle, pseudocyphellae and some types of soralia:

**Table 7**

*Intraspecific contacts between P. sulcata and P. sulcata. Substratums: Quercus robur and vine stocks and vine branches*

| Overgrowth contacts | Line contacts | Window contacts |
|---|---|---|
| $B \widehat{m} B$ | $\underline{B}\ m\ \underline{B}$ | $B \wedge B(W)$ |
| $B \wedge B$ | | |
| $B \widehat{m} B \widehat{m} B$ | | |
| $B \wedge B \wedge B$ | | |
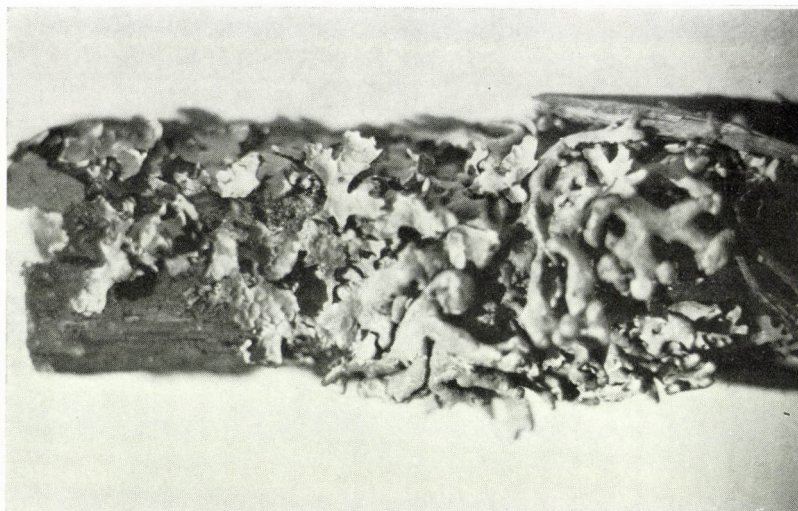
*Fig. 4.* Competition between foliaceus species on a small surface of vine-branch. The species belongs to different ages. On the figure juvenile colonies of *Parmelia sulcata* and older thalli of *Hypogymnia physodes* can be seen. Competition is observable between juvenile colonies, too

manifiform soralia in *Hypogymnia* genera and the rimiform soralia on the upper surface of *Parmelia sulcata* (JAHNS 1973: 46).

On the upper cortex of this species we can find veins in a net-like pattern. The cortex usually breaks along its veins. These vegetative structures and the breakage of the upper cortex give potential surfaces for the formation and development of overgrowth contacts, especially in dense communities where the competition is very strong between species and populations. I have observed a prime example of this on a 4 $cm^2$ surface of a vine-branch, between juvenile species of *Parmelia sulcata* (Fig. 4).

The density and the probability of the formation of overgrowth contacts increases as the colonies grow.

### I.4. Hypogymnia physodes — Parmelia subargentifera var. conspurcata

Both plants were common on vine branches. The morphology of the species is different, especially in the juvenile stage. The competition between these colonies is very strong. The occurrence of line contacts is very rare (Fig. 3b, Table 8).

### I.5. Parmelia subargentifera var. conspurcata — P. subargentifera var. conspurcata

Tables 2 and 9 show that in the cases of intraspecific contacts the roles of the line contacts are more significant than in interspecific contacts.

### I.6. Parmelia sulcata — Parmelia subargentifera var. conspurcata

Only three types of contacts were found between these species. The nearness of the thalli to each other is necessary for the development of contacts. In studied cases it was found that these species were further from one another in most areas (Table 10).

**Table 8**

*Interspecific contacts between Hypogymnia physodes and Parmelia subargentifera var. conspurcata. Substratum: vine-branches*

| Overgrowth contacts | Line contacts | Window contacts |
|---|---|---|
| $B \widehat{m} A$ | $\underline{A}\ m\ \underline{B}$ | $A \wedge B(W)$ |
| $A \widehat{m} B$ | | |
| $A \wedge B$ | | |
| $B \wedge A$ | | |
| $A \widehat{m} B \widehat{m} A$ | | |
| $A \wedge B \wedge A$ | | |

A = *H. physodes*, B = *P. subargentifera* var. *conspurcata*

**Table 9**

*The types of intraspecific contacts*

| Overgrowth contacts | Line contacts |
|---|---|
| $B \widehat{m} B$ | $\underline{B}\ m\ \underline{B}$ |
| $B \wedge B$ | $\underline{B}\ m\ \overline{B}$ |
| $B \widehat{m} B \widehat{m} B$ | $B \parallel B$ |

**Table 10**

*Types of interspecific contacts. Substratum: vine-stock and branches and Quercus robur*

| Overgrowth contacts | Line contacts |
|---|---|
| $A \widehat{m} B$ | $A \parallel B$ |
| $B \widehat{m} A$ | |

A = *P. sulcata*, B = *P. subargentifera* var. *conspurcata*

## *II. Interspecific contacts between foliaceus and crustose species*

"Since the species differ in their basic morphology, there are two kinds of overgrowth and epiphytic growth depending upon which species is overgrown." (PENTECOST 1980.)

In Table 11 there are three kinds of contacts because the development of overgrowth contacts change with the phases of succession. The marginal overgrowth contacts are less common in the terminal phase of succession, but most common in the initial phase of coloniza-

**Table 11**

*Type of contacts between foliaceus and crustose species. Substratum: vine-stock and branches*

| Species | Types of contacts |
|---|---|
| II.1. *H. physodes–B. luteola* | A $\widehat{m}$ B |
| | A ∧ B |
| | A . B |
| II.2. *H. physodes–D. alboatra* | A $\widehat{m}$ C |
| | A ∧ C |
| | A . C |
| II.3. *P. subargentifera* var. *conspurcata–D. alboatra* | D $\widehat{m}$ C |
| | D ∧ C |
| | D . C |

A = *Hypogymnia physodes*, B = *Bacidia luteola*, C = *Diplotomma alboatra*, D = *Parmelia subargentifera* var. *conspurcata*

tion of foliaceus species. In the terminal phase only some of crustose lichens are observable on various surfaces because the foliaceus species overgrow them.

The development of types of contacts between colonies was very well observed on both vine-branches and vine-stocks. The vine-branches were covered with crustose taxons and with juvenile foliaceus species. However on the vine-stocks I observed only foliaceus and fruticose species. Figure 5 shows a model of the development of overgrowth contacts between foliaceus and crustose species.

## *III. Interspecific competition between foliaceus-fruticose species*

The foliaceus and fruticose species differ in their basic morphology and histology. Contrary to laciniate foliose lichens, their lobes are strap-shaped or threadlike with a radial or dorsiventral thallus.

We can distinguish two types of histological constructions in fruticose lichens (Jahns 1973). In some species the hyphae of the cortex serve as supporting tissue (*Evernia prunastri*, *Pseudevernia furfuracea*, etc.). They form a cylindrical tube at the lateral edge of the thallus, while the centre of the colony is hollow or fills a cottony medulla.

This type of construction serves to keep the plant upright and to withstand lateral pressure. In the supporting tissue the hyphae is closely cemented. These histological characteristics provide the basis for the successful competition between foliaceus-fruticose species. On the other hand many strap-shaped thalli are attached to the substrate by a holdfast. Therefore they can exist on very small surfaces, between the lobes of foliaceus species.

In the second type of fruticose lichens the supporting tissue is situated in the centre of the medulla ("axial strand"). The axial strand gives skeletal strength to pendulous taxa (*Usnea* species).

The strap-shaped and threadlike species always vertically overgrow the foliaceus taxa.
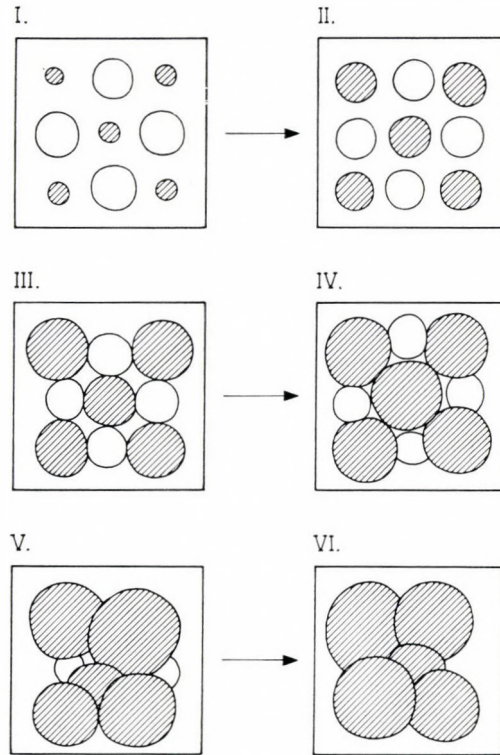
*Fig. 5.* Overgrowth model between foliaceus and crustose species. A = foliaceus species (shaded), B = crustose species (unshaded). Assumptions: both species begin growing at the same time, but the radial growth rate of A is multiple that of B. The lichens grow on a defined surface area. I. Small circular thalli on the surface. There is no contact between them ("open stage"). II. Radial growth of thalli. III. Several "truce" condition between thalli. IV. Marginal overgrowth contacts between foliaceus and crustose species. Between foliaceus colonies only truce condition. V. Overgrowth contacts between foliaceus and crustose colonies. Marginal overgrowth and overgrowth contacts between foliaceus colonies. VI. The foliaceus colonies totally overgrow the crustose thalli

**Table 12**

*The types of overgrowth contacts between foliaceus-fruticose species. Substratums: Picea abies, Pinus silvestris, Quercus robur, vine-stocks and branches*

| | Species | Overgrowth contacts |
|---|---|---|
| III.1. | *H. physodes-Pseudevernia furfuracea* | $A \vee \underline{B}$<br>$B \vee A$ |
| III.2. | *Parmelia exasperatula–Pseudevernia furfuracea* | $A \vee \underline{B}$<br>$B \vee A$ |
| III.3. | *H. physodes–Evernia prunastri* | $B \vee A$ |

*Fig. 6.* Competition between foliaceus (*Hypogymnia physodes*) and fruticose (*Pseudevernia furfuracea*) species. The foliaceus species overgrows the lower part of the fruticose

*Fig. 7.* Interspecific competition between *Pseudevernia furfuracea* and *Usnea hirta* var. *minutissima*. On the photo it can be seen that the threads of *Usnea* overgrow vertically the strap-shaped colony

Figure 6 shows the competition between *Hypogymnia physodes* and *Pseudevernia furfuracea*. The competition between these species is often observable on oak trees (*Quercus petraea*, *Qu. robur*), on *Pinus silvestris* trunks, on *Picea abies* branches and on vine-branches. The competition between *Parmelia exasperatula* and *Pseudevernia furfuracea* was observable solely on vine-branches. The competition between *Hypogymnia physodes* and *Evernia prunastri* is observable primarily on oak trunks, rarely on *Pinus silvestris* and vine-trunks (Table 12).

### *IV. Interspecific competition between fruticose species*

The interspecific competition was observable between *Usnea hirta* var. *minutissima* and *Pseudevernia furfuracea*, on vine-branches (Fig. 7). The figure also shows well that the threadlike *Usnea* taxon vertically overgrow the strap-shaped species. The threads of *Usnea* can come up from the lower surface of the *Pseudevernia furfuracea* between their lobes. The axial skeletal tissue keeps the threads over the thallus of the *Pseudevernia furfuracea*.

## Summary

This study has summarized only the first results of our research on this subject which will be continued later.

The competition between species sheds light on the different types of contacts. The competition was observable between species which belonged to the same or different live forms.

The competition seems to be strongest on small surfaces where the space is too small for taxa. The competition between colonies increases on larger surfaces also if the number of individuals reaches a stage of density. This case generally follows in epiphytic communities in the optimal phase of succession. After the optimal phase, comes a period when the given surface can not support any more thalli. This is the "carrying capacity" of a given space (Odum 1971, Juhász-Nagy and Vida 1978).

From these contacts emerges the importance of using the niche concept. Thus far this has not been applied to lichen ecology, only to bryology (Simon–Szerényi 1975, Slack 1977) and in research of grassland communities in Hungary )(Fekete–Précsényi–Molnár–Melkó 1976, Précsényi–Fekete–Melkó–Molnár 1977a, b, Précsényi–Fekete–Molnár–Melkó–Virágh 1979, etc.).

The negative relationship between the amount of space and the strength of the competition was evident on the grape-vines. On the branches the competition was stronger than on the trunks.

The histological and morphological construction of thalli is a very important component in the aspects of competition.

We have some information about the growth phases and growth rates of lichens (Hale 1967, 1973, Armstrong 1974, 1976, Richardson 1967, Woolhouse 1968, etc.) but we know almost nothing of the dynamics of lichen populations (Hosokawa and Omura 1959, Will and Wolf 1980). Only the research of these problems will insure the progress of lichen ecology.

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# IN VITRO PLANTLETS FROM POTATO SHOOT SEGMENTS

M. MARÓTI[1], J. RUDOLF[2], J. BOGNÁR[1] and B. I. POZSÁR[3]

[1,3]DEPARTMENT OF PLANT TISSUE DEVELOPMENT, LORÁND EÖTVÖS UNIVERSITY, GÖD, [2]DEPARTMENT FOR IRRIGATION OF HORTICULTURE UNIVERSITY, AND [3]DEPARTMENT OF ORGANIC CHEMISTRY, INSTITUTE OF ISOTOPES OF HUNGARIAN ACADEMY OF SCIENCES. BUDAPEST HUNGARY

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Conditions of in vitro vegetative micro-propagation of four potato cultivars (*Solanum tuberosum* L. Bintje, Desiré, Gracia, Ostara) have been studied. The investigations included determination of optimum shoot inocula and comparison of the effects of various culture media. According to the results shoots most suitable for isolation developed from tubers given no previous treatment, and the highest regeneration ability was displayed by the basal and apical segments of the shoots. The cultivars showed the following order of regeneration potential: Ostara, Gracia, Desiré, Bintje. The organizational efficiency of the culture media greatly depends on the regulators contained in them, and on their concentrations and interactions. The largest number of plantlets developed on a MURASHIGE–SKOOG (1962) culture medium containing 0.5 mg/l NAA, 0.4 mg/l Kn and 0.7 mg/l thiamine, too. The results show that the method employed is suitable for the in vitro vegetative propagation of potato, but the differences being rather great between the cultivars must be taken into consideration.

## Introduction

Potato is going to play an increasing role in the world supply of food (MURASHIGE 1978). That is why experiments with a view to its reliable and pathogen-free propagation have been started all over the world. Among them important role is played by the in vitro vegetative micro-propagation, since this method is pathogen-free, and may even form the basis of working technologies (MARÓTI 1978, MELLOR and STACE-SMITH 1977, MURASHIGE 1978, NOSERAN et al. 1977, QUAK 1977, WESTCOTT et al. 1977). Results obtained so far with meristem cultures show that there are considerable differences in regeneration potential between the cultivars (BEHNKE 1975, 1976, LAM 1977, ROCA et al. 1978, SOPORY 1977, SOPORY and ROGAN 1976). It is therefore desirable to elaborate special propagation methods adaptable to the different cultivars. So it is important to know the proper way of inducing shoot growth from the tubers, find the best regenerating segments of shoots, get acquainted with the effects of culture media and stimulators as well as with the conditions of laboratory incubation, etc. The objective set in our experiments was to find the optimum shoot segments on the one hand, and establish the effects of various culture media, on the other.

## Materials and methods

Four cultivars of potato (*Solanum tuberosum* L. Bintje, Desiré, Gracia, Ostara) were included in our experiments. Tubers of about 4 cm in diameter were thoroughly washed in tap water, then placed in Petri dishes and forced with or without previous treatment at a temperature of 22 ± 2 °C in diffuse light day and night alternately. One of the pretreatments consisted of dipping the intact tubers first into 70% ethylic alcohol then into 50% solution
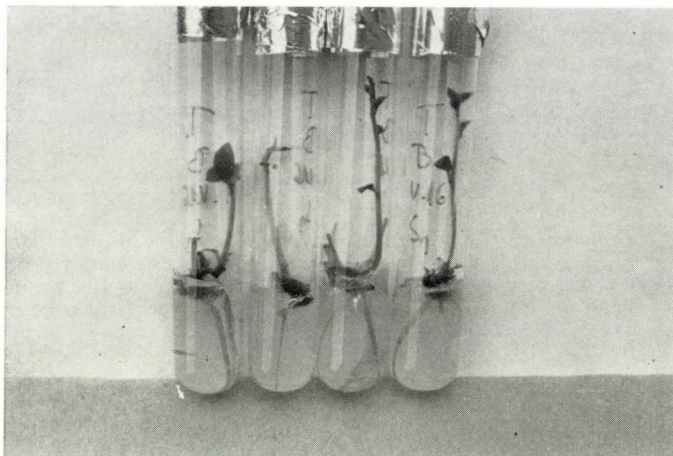
*Fig. 1.* Development of inocula of *Solanum tuberosum* L. cv. Bintje isolated from the basal segment of shoot on medium A after the 21st day

of Ca-hypochlorite for 15 minutes, then washing them in distilled water. The other pretreatment was the following: pieces of about 0.5 $cm^3$ each bearing shoots were excised from the tubers previously washed in tap water, and placed in Petri dishes on a talcum surface containing 2 mg/kg $GA_3$ which was kept constantly wet. From the tubers and explants, respectively, 1–4 cm long shoots grew in 2–3 weeks, from the apical or nodal segments of which 1–5 mm long inocula were prepared. The inocula were sterilized again in 70% ethylic alcohol (for 0.1 minute) and 25% Ca-hypochlorite solution (for 15 minutes), then washed twice in distilled water.

Besides the mineral elements of the culture medium of MURASHIGE–SKOOG (1962) the basal medium used in the experiment contained 0.5 mg/l nicotinic acid-HCl, 0.5 mg/l pyridoxine-HCl, 2.0 mg/l glycine, further 0.1 mg/l $GA_3$ and 30 g/l saccharose as fixed components. The agar concentration was 0.8%. The pH was adjusted to 5.8 before the autoclave treatment. By changing the kind and ratio of regulators we produced 6 variants of culture medium (mg/l): A) Indole-3-acetic acid (IAA) 0.5 — Kinetin (Kn) 0.04 — Thiamine-HCl ($B_1$) 0.1; B) The same as A) but without agar, a liquid medium (with paper bridge); C) Naphthylene-acetic acid (NAA) 0.05 — Kn 0.4 — $B_1$ 0.1; D) NAA 0.5 — Kn 0.4 — $B_1$ 0.7; E) Indolebutyric acid (IBA) 1.0 — Kn 0.5 — $B_1$ 0.7; F) IBA 2.0 — Kn 0.5 — $B_1$ 1.0 (Figs 1, 2a, 2b).

The inocula excised from the shoots were grown in $12 \times 100$ mm test-tubes on 5 $cm^3$ culture medium at 30 $\pm$ 2 °C with a 16 hour illumination and 8 hour dark period. Illumination was supplied by Orion 20 WF. 7-Day light and Tungsram 20 WF. 30-White type fluorescent lamps (120 $W/m^2$). The period of incubation was 4 weeks. In each experiment 50 isolates were generally used. The results were put to qualitative evaluation and summed up in a table.

Within 4–8 weeks the primary isolates developed callus, or 4–5 cm long shoots, or regenerated intact plantlets. These were cut again into 0.5 cm segments and used for propagation, since from the nodes new shoots can be regenerated. After reaching a length of 5–6 cm — and root initiation had also begun — the healthy plantlets were transferred from the sterile culture medium to a 4 : 1 : 1 ratio mixture of autoclaved loam, sand and pearlite filled into plastic cups. The plantlets were covered one by one with glass for a week to prevent an excessive evaporation, and irrigated every 2 to 4 days with Knop solution (Fig. 2).

## Results and discussion

In our experiments we found the most and the strongest shoots to develop from the untreated tubers, and that after 2–3 weeks. Shoots developing from a single sprout sometimes were even 4–5 in number, divided into
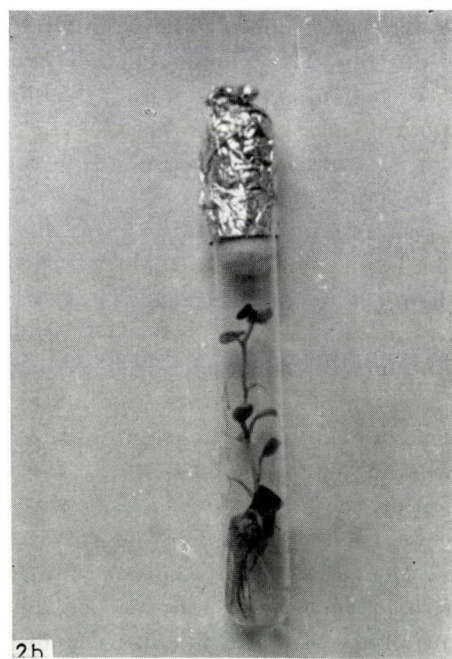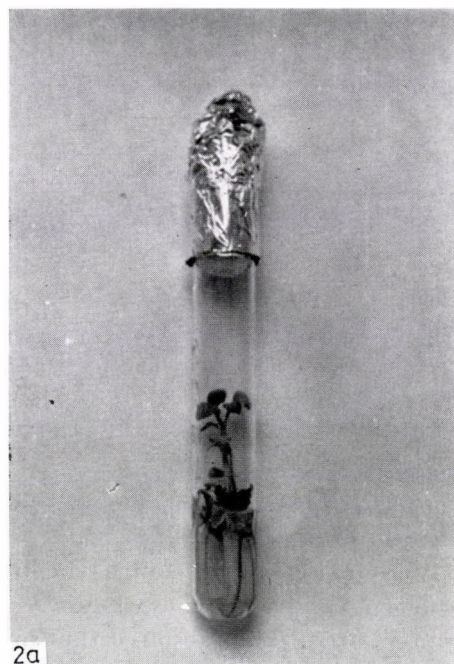
*Fig. 2.* Plantlet of *Solanum tuberosum* L. cv. Ostara isolated from shoot segment on medium D after the 3rd (a) and 4th (b) week

**Table 1**

*Development of potato (Solanum tuberosum L.) cultivars*

| Culture media | Regulators, mg/l | | | | | Development responses of | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Bintje | | |
| | IAA | NAA | IBA | Kn | $B_1$ | C | Sh | P |
| A | 0.5 | — | — | 0.04 | 0.1 | ++ | ++ | ++ |
| B* | 0.5 | — | — | 0.04 | 0.1 | — | — | — |
| C | — | 0.05 | — | 0.4 | 0.1 | ++ | + | + |
| D | — | 0.5 | — | 0.4 | 0.7 | + | +++ | +++ |
| E | — | — | 1.0 | 0.5 | 0.7 | + | ++ | + |
| F | — | — | 2.0 | 0.5 | 1.0 | ++ | ++ | ++ |

Abbreviations: C — callus, Sh — shoot, P — plantlet

leafy nodes and internodes. From the sterilized tubers shoots developed only after 4–5 weeks. They were inferior to the control shoots in length, thickness, number of leaves and leaf area as well. They showed reduced growth on the different culture media too. Sterilization resulted thus in expressed inhibition. The $GA_3$-talc treatment also hindered both the beginning of the shoot development and the subsequent growth of shoots. The shoot axes remained thin and the leaf surface did not exceed 1–2 $mm^2$. They exhibited poor development on a sterile culture medium too. This phenomenon is brought into connection with the low nutrient reserves of explants and the lack of stimulators required for the initiation of shoot development.

The results of our experiments carried out to establish the regeneration potential of shoot segments — intact plant — show the differences between the cultivars. The largest number of plantlets suitable for further culturing were obtained from the basal segments of shoots, less from the apical inocula and least of all from the medial nodes of shoots. The cultivars' order of regenerating plantlets on the same medium (A) was: Ostara, Gracia, Desiré, Bintje. This order of succession remained unchanged with the other culture media, too.

The regeneration potentials of culture media and regulators are shown in Table 1. In the course of evaluation the origin of the inocula (basal, apical or medial segment) was left out of consideration. The results show that the rate of callus formation on the inocula of cultivars was more or less the same on all culture media except medium **B**. Shoot organization was more intensive than callus formation. Development into intact plantlets was somewhat retained by the slowness of root formation; the cultivars' order of plantlet regeneration was essentially the same on all culture media used as on medium **A**.

When comparing the actions of culture media **A** and **B** we find the organization potential of the solid (agar) medium to exceed by far that of

*on various culture media after 4 weeks at 30 ± 2 °C*

| potato cultivars | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Desiré | | | Gracia | | | Ostara | | |
| C | Sh | P | C | Sh | P | C | Sh | P |
| + | +++ | ++ | ++ | +++ | +++ | ++ | +++ | +++ |
| + | + | — | + | + | — | + | + | — |
| ++ | + | + | ++ | + | + | ++ | + | + |
| + | +++ | +++ | + | +++ | +++ | + | +++ | +++ |
| + | ++ | ++ | + | ++ | + | + | ++ | ++ |
| ++ | ++ | + | + | ++ | ++ | + | ++ | ++ |

Symbols: — no development, + slight development, ++ medium development, +++ intensive development, * liquid culture medium without agar, with filter-paper bridge

the liquid (paper bridge) medium. A comparison between media **C** and **D** reveals that higher concentrations of NAA and thiamine ($B_1$) considerably increase the organ formation and the development of plantlets. The optimum interaction of the two compounds makes its effect felt in every cultivar. From
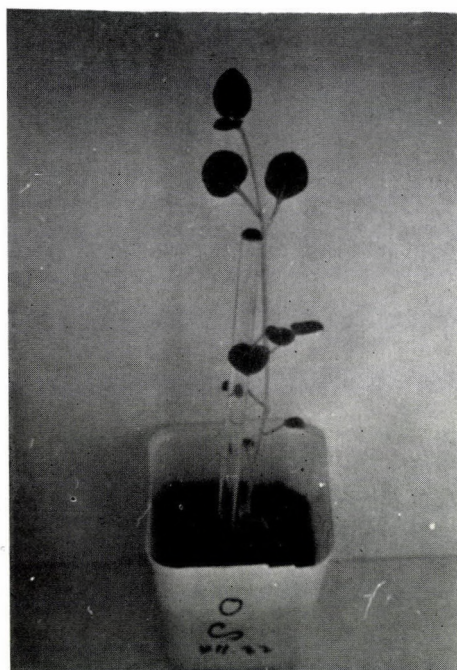
*Fig. 3.* Plantlet of *Solanum tuberosum* L. cv. Ostara transferred to a mixture of loam, sand and pearlite, after six weeks

the results of variants **E** and **F** we have drawn the conclusion that neither IBA and its growing concentrations on the one hand, nor the interactions changed by the higher concentrations of Kn and $B_1$, on the other, increase the root formation and general organization of inocula. As to the order of efficiency of the culture media applied: the largest number of plantlets regenerated on media **D** and **A**, while the fewest of them on those marked **C** and **B**. The efficiency was due partly to the compounds used and their concentrations, respectively, partly to the appropriate interactions of the compounds as confirmed by the data of the relevant literature (Mellor and Stace-Smith 1977, Quak 1977, Pennazio et al. 1976, Roca et al. 1978, Tóth and Maróti 1979).

The plantlets regenerated from various shoot segments were transferred to plastic cups generally after 6–7 weeks (Fig. 3).

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# GROWTH DYNAMICS OF THE CALLUS TISSUES OF PETAL AND OVARY ORIGIN OF THE *DATURA INNOXIA* MILL.

Á. POTOCZKI, É. SZŐKE and G. VERZÁR-PETRI

INSTITUTE OF PHARMACOGNOSY, SEMMELWEIS MEDICAL UNIVERSITY, BUDAPEST, HUNGARY

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The effect of growth regulators (kinetin and 2,4-D) on the growth of the callus tissues of flower (petal, ovary) origin of the 3 year-old *Datura innoxia* Mill. has been examined.

The proper concentration of the growth regulators was determined for the formation of the optimum biomass. We have examined the growth dynamics of the tissues grown in light and dark in a modified MURASHIGE–SKOOG medium containing 1 mg/l of kinetin and 1 mg/l of 2,4-D which were found to be the optimum ratios. During the incubation period (6 weeks) the fresh and dry weights, the daily growth rate and growth values of the callus tissues were measured. It was established that both callus tissues were gradually growing during the six weeks. With cultures of both petal and ovary origins the growth value related to the fresh and dry weights was considerably higher in dark than in light (Tables 3 to 6). The daily growth had a maximum value in all instances. The growth of the tissue cultures — excepting the petal grown in light — slowed down in the sixth week.

The growth value of callus tissues of petal origin, related to the dry weight is higher in media without kinetin than in the basic one (1 mg/l of kinetin, 1 mg/l of 2,4-D).

## Introduction

Medicaments of plant origin have been playing an ever more important role in therapeutics and pharmaceutical industry, respectively. Alkaloids as secondary metabolic products are very often responsible for the desired effect.

Amongst several test materials the *Datura* genus was also subjected to a thorough examination, and up till now 30 alkaloids have been identified from the genus (EVANS et al. 1953, LIEBISCH et al. 1966, VERZÁR-PETRI 1971). Besides the alkaloids already known in therapeutics newer efficacious compounds have been found. Recently the alkaloid-extract of the flower of *Datura innoxia* has been used for anaesthetization in surgical operations in China (SHANGHAI TRADITIONAL MEDICINE ANESTHESIA RESEARCH COORDINATING GROUP 1975, XIAO PEIGEN 1980). This was why we decided to produce tissue cultures also from the flower of *Datura innoxia* in order to study the secondary metabolic products (VERZÁR-PETRI et al. 1980).

Up till now many researchers have dealt with the biomass formation and alkaloid production of the callus tissues of various origin of *Datura innoxia*. Examining *Datura innoxia* plants grown in phytotrone, COSSON (1969) found that light had exerted a positive influence on the alkaloid production, hence he cultivated the tissue cultures, too, under light of a fluorescent lamp of 8000 Lux. SMORODIN (1974) examined the effect of the temperature with respect to the biomass production and total alkaloid contents of the callus tissues, and in connection with this he established that the growth of the tissues is most intensive at 26 °C while strongly checked under 18 °C and above 35 °C. In connection with the tissue production
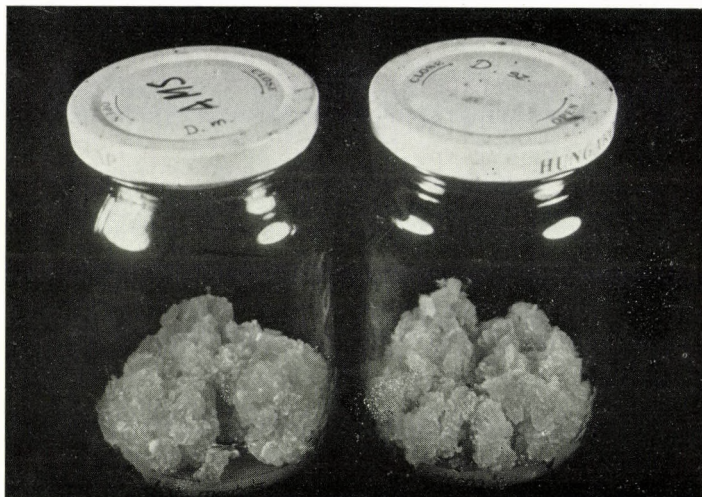
*Fig. 1.* Callus tissues of ovary (left) and petal (right) origins of six week old *Datura innoxia*

of *Datura innoxia* HIRAKOA's work must be stressed by all means. He produced callus and suspension cultures from various *Datura* species. Among others he examined also the effect of light on the growth and alkaloid production of the callus tissues of *Datura innoxia.* He established that the dry weight and alkaloid contents of the cultures grown in dark are less than those of the cultures grown in light (HIRAOKA 1976).

Concerning the alkaloid contents, VERZÁR-PETRI et al. (1978) obtained similar results for the callus cultures of root and leaf origins of *Datura innoxia* but they found the biomass formation more intensive in dark (DUNG et al., in press). Concerning callus tissues of flower origin, data were not at our disposal so we thought it particularly necessary — before examination of alkaloid production — to study the growth of the tissues.

## Material and methods

Three-year old cultures produced from the flower (ovary and petal) of *Datura innoxia* Mill. were grown in dark and in light (2500 Lux.), in modified MURASHIGE–SKOOG media at 26 °C with 70% relative air humidity (Fig. 1). The cultures were grafted into fresh media every 4–5 weeks.

For the examinations relating to the growth dynamics of the cultures and effect of growth stimulating materials the tissues were grown in eprouvettes containing 20 ml media. The tests were repeated ten times.

At the end of the six-week growth period the fresh and dry weights of the callus were determined in each eprouvette, and the results were statistically appraised (GORDON et al. 1976). For characterizing the growth activity of the tissues we used the very same indexes as SZŐKE et al. (1979) did when they analysed the callus tissues of the *Matricaria chamomilla* L.

1. Fresh weight of the tissues in g
2. Dry weight of the tissues in mg
3. Growth value (GV):

$$GV = \frac{P_t - P_0}{P_0}$$

where $P_t$ = weight of the tissue at the end of the experiment
$P_0$ = starting-weight of the tissue at the grafting (NICKELL 1956).

The growth value was calculated both for the fresh and dry weights of the tissues.

4. Contents of dry material of the tissues in per cent.

5. Growth speed of the tissues viz., the daily growth of the fresh weight of the tissues (Maróti 1976). In the examinations relating to the growth dynamics of the tissues this value was calculated every week. In the experiments performed with the application of materials stimulating the growth, the end-weight of the callus was used for the calculations. Rubbing preparations were made for microscopic examinations. The alkaloids were indicated by histochemically modified Dragendorff-reagent (Verzár-Petri 1973).

## Experimental results and their assessment

Growing *in dark*, the callus tissues produced from the flower (ovary and petal) of *Datura innoxia* Mill. — similarly to the callus tissues of root and leaf origins produced in our institute — are homogeneous cultures consisting of loose, parenchymatous cells of yellowish colour. The callus tissues of ovary origin are morphologically similar to the callus tissues of petal origin. There were no signs of organogenesis in either of the cases (Fig. 1). From a light-microscopic analysis it has been established that the shape of the cells varies both in the ovary and petal tissue cultures. In the tissues of ovary origin band-like and roundish cell forms can generally be seen (Fig. 2) while the roundish cell form is dominating in cultures of petal origin.

During histochemical examinations the presence of crystals, which gave positive alkaloid reaction to the effect of Dragendorff-reagent, was observed in the individual idioblasts.

The stand of the tissue cultures of ovary and petal origins grown *in light* became more solid but there were no signs of organogenesis even then, in contrary to the cultures of leaf origin in which extremely many tracheae were formed due to lighting. It must be mentioned that in the cultures of petal origin starting from the third week of the growth season steadily intensifying green spots could be observed due to the lighting, referring to chlorophyll formation. In such tissues the presence of chloroplasts can definitely be established by light-microscope.

Before thorough chemical examinations the effects of the concentration of the growth controllers on the growth of the tissues were examined. Our aim was to choose a culture medium of optimum hormonal concentration.
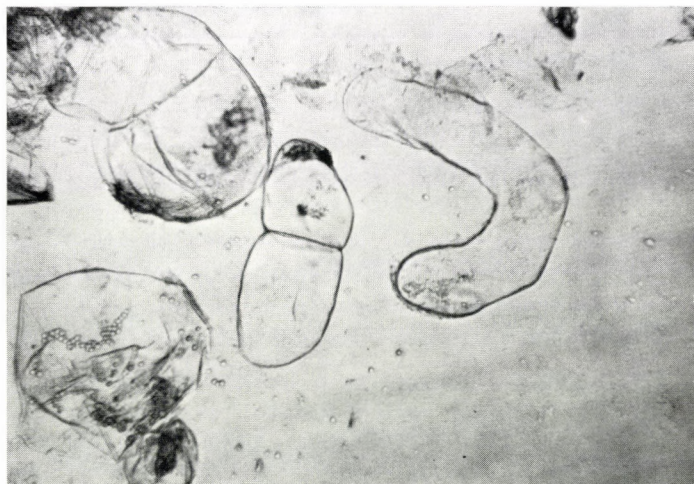
*Fig. 2.* Cells of various shape of the callus tissue of ovary origin (obj.: ×8; proj.: ×6.3)

**Table 1**

*The effect of growth regulators — kinetin and 2.4-D — on the growth of callus tissues of ovary origin of Datura innoxia*

| Serial number of experimental variants | Concentration, mg/l | | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV relating to | | Growth rate, mg/day |
|---|---|---|---|---|---|---|---|---|
| | kinetin | 2,4-D | | | | fresh-weight | dry-weight | |
| 1 | 0 | 1 | 1.8237 ± 0.1467 | 84.5905 | 4.6384 | 11.6910 | 18.6452 | 40.0000 |
| 2 | 0.2 | 1 | 2.4045 ± 0.2429 | 107.5436 | 4.4726 | 15.7328 | 23.9759 | 53.8286 |
| 3 | 0.5 | 1 | 2.4920 ± 0.2971 | 110.4853 | 4.4336 | 16.3417 | 24.6590 | 55.9119 |
| 4 | 1 | 1 | 3.2462 ± 1.2366 | 121.5669 | 3.7449 | 21.5901 | 27.2326 | 73.8690 |
| 5 | 2 | 1 | 2.9388 ± 0.7712 | 103.6779 | 3.5279 | 19.4509 | 23.0781 | 66.5500 |
| 6 | 5 | 1 | 0.6079 ± 0.2741 | 33.4460 | 5.5019 | 3.2303 | 6.7675 | 11.0524 |
| 7 | 10 | 1 | 0.2979 ± 0.0674 | 16.5906 | 5.5692 | 1.0731 | 2.8529 | 3.6714 |
| 8 | 1 | 0 | 0.9005 ± 0.3859 | 59.2682 | 6.5817 | 5.2665 | 12.7644 | 18.0190 |
| 9 | 1 | 0.2 | 1.9216 ± 0.3746 | 84.5965 | 4.4024 | 12.3716 | 18.6466 | 42.3286 |
| 10 | 1 | 0.5 | 3.2913 ± 0.4920 | 123.6475 | 3.7568 | 21.9040 | 27.7158 | 74.9429 |
| 11 | 1 | 1 | 3.2462 ± 1.2366 | 121.5669 | 3.7449 | 21.5901 | 27.2326 | 73.8690 |
| 12 | 1 | 2 | 3.0126 ± 1.2283 | 114.4908 | 3.8004 | 19.9645 | 25.5893 | 68.3071 |
| 13 | 1 | 5 | 0.3494 ± 0.1868 | 19.3749 | 5.5452 | 1.4324 | 3.4996 | 4.8976 |
| 14 | 1 | 10 | 0.1508 ± 0.0444 | 8.6862 | 5.7601 | 0.4941 | 1.0173 | 0.1690 |

**Table 2**

*The effect of growth regulators — kinetin and 2,4-D — on the growth of callus tissue of petal origin of Datura innoxia*

| Serial number of experimental variants | Concentration, mg/l | | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV relating to | | Growth rate, mg/day |
|---|---|---|---|---|---|---|---|---|
| | kinetin | 2,4-D | | | | fresh-weight | dry-weight | |
| 1 | 0 | 1 | 4.6192 ± 0.3352 | 167.8894 | 3.6346 | 30.6600 | 28.7718 | 106.5071 |
| 2 | 0.2 | 1 | 4.5034 ± 0.3769 | 159.9112 | 3.5509 | 29.8663 | 27.3571 | 103.7500 |
| 3 | 0.5 | 1 | 3.6875 ± 0.4314 | 135.6115 | 3.6776 | 24.2742 | 23.0480 | 84.3238 |
| 4 | 1 | 1 | 4.5192 ± 0.4406 | 149.5042 | 3.3082 | 29.9746 | 25.5116 | 104.1262 |
| 5 | 2 | 1 | 4.6048 ± 0.4829 | 148.5554 | 3.2261 | 30.5613 | 25.3433 | 106.1643 |
| 6 | 5 | 1 | 0.9993 ± 0.1536 | 48.1223 | 4.8156 | 5.8492 | 7.5335 | 20.3190 |
| 7 | 10 | 1 | 0.4500 ± 0.0105 | 25.2697 | 5.6155 | 2.0843 | 3.4811 | 7.2405 |
| 8 | 1 | 0 | 1.7818 ± 0.5895 | 105.9868 | 5.9483 | 11.2125 | 17.7946 | 38.9500 |
| 9 | 1 | 0.2 | 2.2766 ± 0.7078 | 121.7548 | 5.3481 | 14.6038 | 20.5908 | 50.7309 |
| 10 | 1 | 0.5 | 2.3581 ± 1.6408 | 102.9499 | 4.3658 | 15.1624 | 17.2561 | 52.6714 |
| 11 | 1 | 1 | 4.5192 ± 0.4406 | 149.5042 | 3.3082 | 29.9746 | 25.5116 | 104.1262 |
| 12 | 1 | 2 | 3.3435 ± 0.9109 | 116.1799 | 3.4748 | 21.9164 | 19.6022 | 76.1333 |
| 13 | 1 | 5 | 0.3154 ± 0.0526 | 16.2614 | 5.1558 | 1.1618 | 1.8836 | 4.0357 |
| 14 | 1 | 10 | 0.1174 ± 0.0000 | 7.3846 | 6.2901 | 0.0000 | 0.3095 | 0.0000 |

Tables 1 and 2 show the growth results of the callus tissues of ovary and petal origins grown in dark in the basic medium with various auxin and kinetin concentrations. There were no signs of organogenesis in either of the experimental variants (Figs 3, 6). The *ovary* callus tissues grew most intensively with the following portioning: 1 mg/l of kinetin and 1 mg/l of 2,4-D (ratio 1 : 1) or 1 mg/l of kinetin and 0.5 mg/l of 2,4-D, respectively (ratio 1 : 0.5). The growth is relatively intensive even with 1 mg/l of kinetin and 2 mg/l of 2,4-D or 2 mg/l of kinetin and 1 mg/l of 2,4-D (Fig. 4). Applying a larger amount of kinetin and 2,4-D concentration, the cultures grew a little or not at all. In cases like these the tissues became more solid and their dry material contents increased considerably (Fig. 5).

The *petal* callus tissues also increased intensively in a medium with 1 mg/l of kinetin and 1 mg/l of 2,4-D. Increasing the kinetin concentration to 2 mg/l (with 1 mg/l of 2,4-D), the growth value of the callus tissues shows a similar value as when applying 1 mg/l of kinetin (Table 2). It is interesting, however, that growing the tissue in a medium without kinetin (1 mg/l of 2,4-D), the growth value — relating to dry weight mainly — exceeds that of the tissues grown in the basic medium (1 mg/l of kinetin and 1 mg/l of 2,4-D) having nearly the same fresh weight and daily growth but less content of dry material. In a medium without
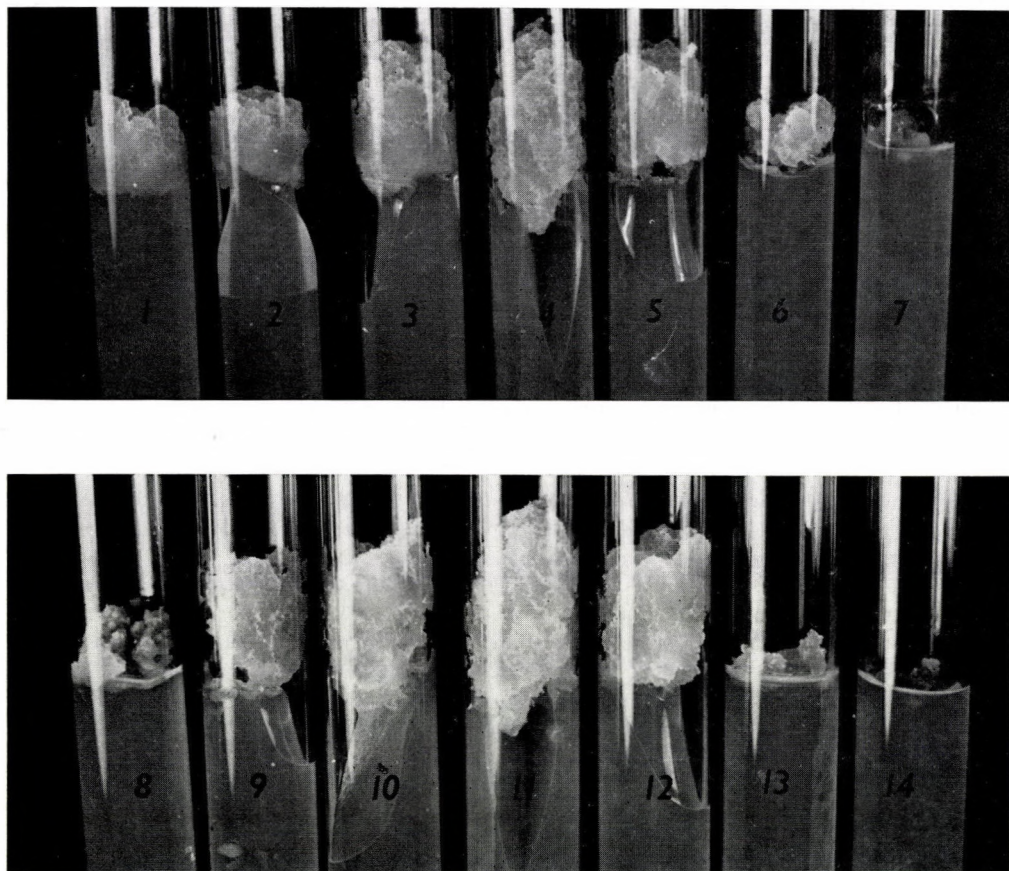
*Fig. 3.* Effect of growth regulators on the growth of callus tissue of ovary origin of *Datura innoxia* (the serial number of the experimental variants corresponds to those given in Table 1)
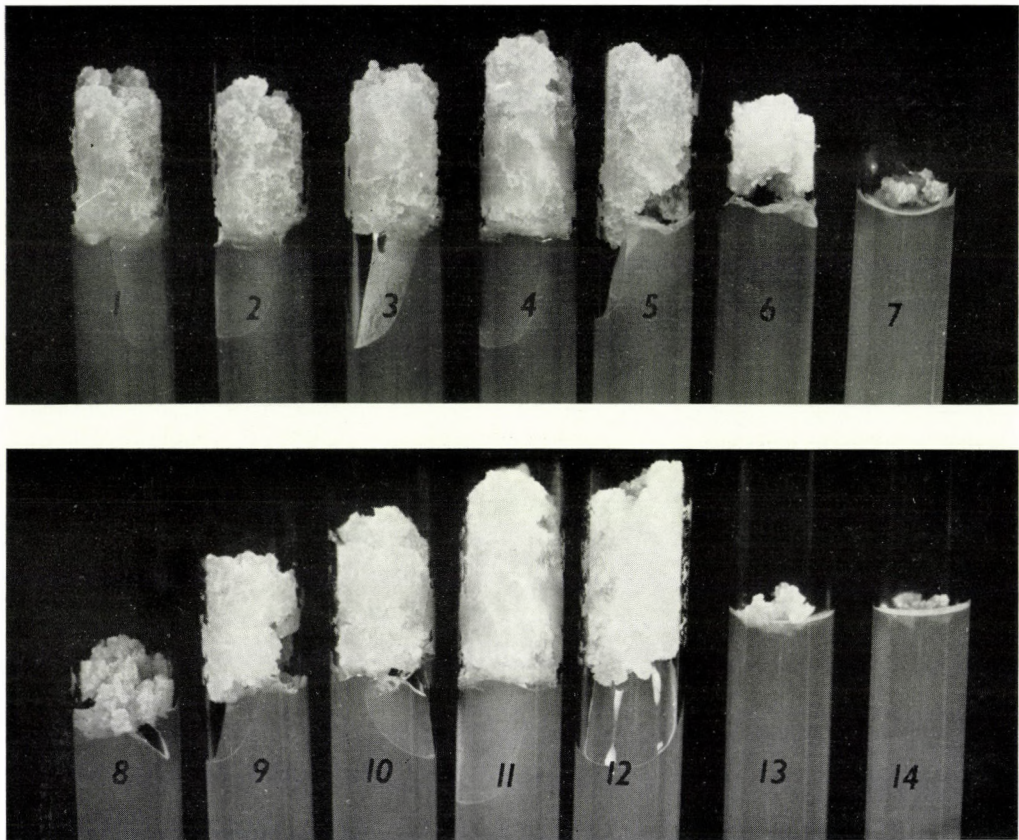
*Fig. 4.* Effect of growth regulators on the growth of the callus tissue of petal origin of *Datura innoxia* (the serial number of the experimental variants corresponds to those given in Table 2)

kinetin the growth of cultures shows a similar intensity through more graftings. So the cultures of petal origin are supposed to have their own cytokinin synthesis, which assures the development of the tissues.

Similarly to the ovary callus tissues the growth of the tissues is strongly checked by increased concentrations of kinetin (5 and 10 mg/l) with a stable, i.e. identical concentration of 2,4-D (1 mg/l) and by increased concentrations of 2,4-D (5 and 10 mg/l) with a stable concentration of kinetin (1 mg/l).

Adding 1 mg/l of kinetin and 2,4-D, an intensive growth was experienced both in ovary and petal callus tissues, hence we performed the examination of growth dynamics in basic media, in dark and in light, using this concentration. The purpose of these examinations was to establish within how many weeks the tissues would have reached their maximum weight (for the purpose of chemical examinations).

In Tables 3 and 5 the results are shown which characterize the growth of callus tissues of ovary and petal origin grown *in dark*. During 6 weeks the fresh and dry weights of the callus considerably increased. In case of callus cultures of petal origin the daily growth of the fresh weight is intensive in the first week but mainly, in the period between the second and fourth

weeks (it increases by 35 times at the end of the period). With respect to the ovary the daily growth was most intensive between the third and fourth weeks (Figs 5A and 6A). Its growth intensity is slightly slower than in that of petals (the tissues grow 25 times the size of the starting-weight at the end of the period). The dry material contents of the tissues reach the peak in the period between the first and second weeks in both cases. By the end of the growth season the water contents increase due to the growth of the cells (enlargement, expansion) and so the dry material content of the tissues gradually decreases (Figs 5A and 6A).

**Table 3**

*Growth dynamics of callus tissue of ovary origin of Datura innoxia grown in dark in the basic medium*

| Incubation period (week) | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV according to fresh-weight | Growth value, GV according to dry-weight | Growth rate, mg/day (based on rate of weekly growth) |
|---|---|---|---|---|---|---|
| 0 | 0.1817 | 6.4080 | 3.5267 | | | |
| 1 | 0.3279 ± 0.0740 | 17.1256 | 5.2228 | 0.8046 | 2.3225 | 20.88 |
| 2 | 0.7187 ± 0.0807 | 37.7051 | 5.2463 | 2.9554 | 6.3152 | 55.82 |
| 3 | 1.2705 ± 0.2868 | 61.2622 | 4.8219 | 5.9923 | 10.8856 | 78.83 |
| 4 | 2.7105 ± 0.2453 | 105.6010 | 3.8960 | 13.9174 | 19.4879 | 205.70 |
| 5 | 3.8382 ± 0.1544 | 135.3618 | 3.5267 | 20.1238 | 25.2619 | 161.10 |
| 6 | 4.3231 ± 0.5728 | 136.1698 | 3.1498 | 22.7925 | 25.4185 | 69.27 |

**Table 4**

*Growth dynamics of the callus tissue of ovary origin of Datura innoxia grown in light in the basic medium*

| Incubation period (week) | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV according to fresh-weight | Growth value, GV according to dry-weight | Growth rate, mg/day (based on rate of weekly growth) |
|---|---|---|---|---|---|---|
| 0 | 0.2609 | 11.6906 | 4.4809 | | | |
| 1 | 0.4772 ± 0.0554 | 27.9491 | 5.8569 | 0.8290 | 1.3907 | 30.90 |
| 2 | 0.6190 ± 0.1028 | 39.3164 | 6.3516 | 1.3725 | 2.3630 | 20.25 |
| 3 | 1.0165 ± 0.1882 | 58.2231 | 5.7278 | 2.8961 | 3.9803 | 56.78 |
| 4 | 1.9053 ± 0.6406 | 87.7143 | 4.6037 | 5.2695 | 5.7829 | 126.97 |
| 5* | 2.5934 ± 0.7817 | 116.8430 | 4.5054 | 8.9402 | 8.9946 | 98.30 |
| 6* | 2.4045 ± 0.5386 | 107.8370 | 4.4848 | 6.9121 | 7.3410 | |

* On week 0 the fresh weight of the callus is 0.3039 g/culture, its contents of dry material is 4.2542%

**Table 5**

*Growth dynamics of the callus tissue of petal origin of Datura innoxia grown in dark in the basic medium*

| Incubation period (week) | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV according to fresh-weight | Growth value, GV according to dry-weight | Growth rate, mg/day (based on rate of weekly growth) |
|---|---|---|---|---|---|---|
| 0 | 0.1407 | 4.4687 | 3.1761 | | | |
| 1 | 0.4111 ± 0.0763 | 21.4421 | 5.2158 | 1.9205 | 4.2235 | 38.62 |
| 2 | 0.7053 ± 0.0793 | 37.1537 | 5.2678 | 4.0106 | 8.0510 | 42.02 |
| 3 | 1.5023 ± 0.2467 | 67.3977 | 4.4863 | 9.6727 | 15.4188 | 113.80 |
| 4 | 3.0083 ± 1.6049 | 105.4740 | 3.5061 | 20.3718 | 24.6946 | 215.10 |
| 5 | 4.0791 ± 0.4162 | 129.5563 | 3.1761 | 27.9791 | 30.5614 | 152.90 |
| 6 | 5.1640 ± 0.3843 | 150.4531 | 2.9135 | 35.6866 | 35.6521 | 154.90 |

**Table 6**

*Growth dynamics of the callus tissue of petal origin of Datura innoxia grown in light in the basic medium*

| Incubation period (week) | Fresh-weight of callus, g/culture | Dry-weight of callus, mg/culture | Contents of dry material, % | Growth value, GV according to fresh-weight | Growth value, GV according to dry-weight | Growth rate, mg/day (based on rate of weekly growth) |
|---|---|---|---|---|---|---|
| 0 | 0.3120 | 12.0622 | 3.8661 | | | |
| 1 | 0.3473 ± 0.0042 | 19.7617 | 5.6901 | 0.1131 | 0.6383 | 5.04 |
| 2 | 0.4120 ± 0.0657 | 26.8385 | 6.5142 | 0.3205 | 1.2250 | 9.24 |
| 3 | 0.6059 ± 0.0970 | 39.8536 | 6.5776 | 0.9419 | 2.3040 | 27.70 |
| 4 | 1.3892 ± 0.4919 | 78.5454 | 5.6540 | 3.4525 | 5.5117 | 111.90 |
| 5 | 1.9811 ± 0.8654 | 100.3684 | 5.0663 | 5.3496 | 7.3209 | 84.55 |
| 6 | 4.1194 ± 0.6515 | 151.8575 | 3.6864 | 12.2032 | 11.5895 | 305.47 |

The daily growth of both callus tissues grown in basic media *in light*, related to the fresh weight, has two intensive periods (Tables 4, 6; Figs 5B, 6B). In case of cultures of ovary origin the lower maximum value manifests itself already in the first week while the higher one, in the fourth week. The most intensive growth period is that between the second and fourth weeks. In case of cultures of petal origin a few weeks' shift can be seen in the growth. The lower maximum value manifests itself only in the fourth week while the higher one, in the sixth week. It should be mentioned that the growth intensity of the callus tissues of ovary origin is higher up to the fifth week than that of the cultures of petal origin but the development ceases after the fifth week. The dry material contents of the tissues grown in light hits the peak in the second or second and third weeks, respectively.

Comparing the growth value of cultures (relating to fresh and dry weights) grown in dark and light, it was established that the growth intensity of the cultures of both ovary and petal origins is considerably higher in dark than in light.

For the sake of completeness it must be noted that the dry material contents of the callus tissues of ovary and petal origins grown in dark is almost identical at the beginning of the growth season but later the petal cultures show lower values, compared to the cultures grown in light where the dry material contents of the callus tissues of ovary origin show a lower value. Comparing the light conditions, the contents of dry material of the callus tissues of both ovary and petal origins is lower in dark than in light.

In our institute observations parallel to the examinations of callus tissue of flower origin of Datura innoxia were carried out also for the root and leaf callus tissues of the plant
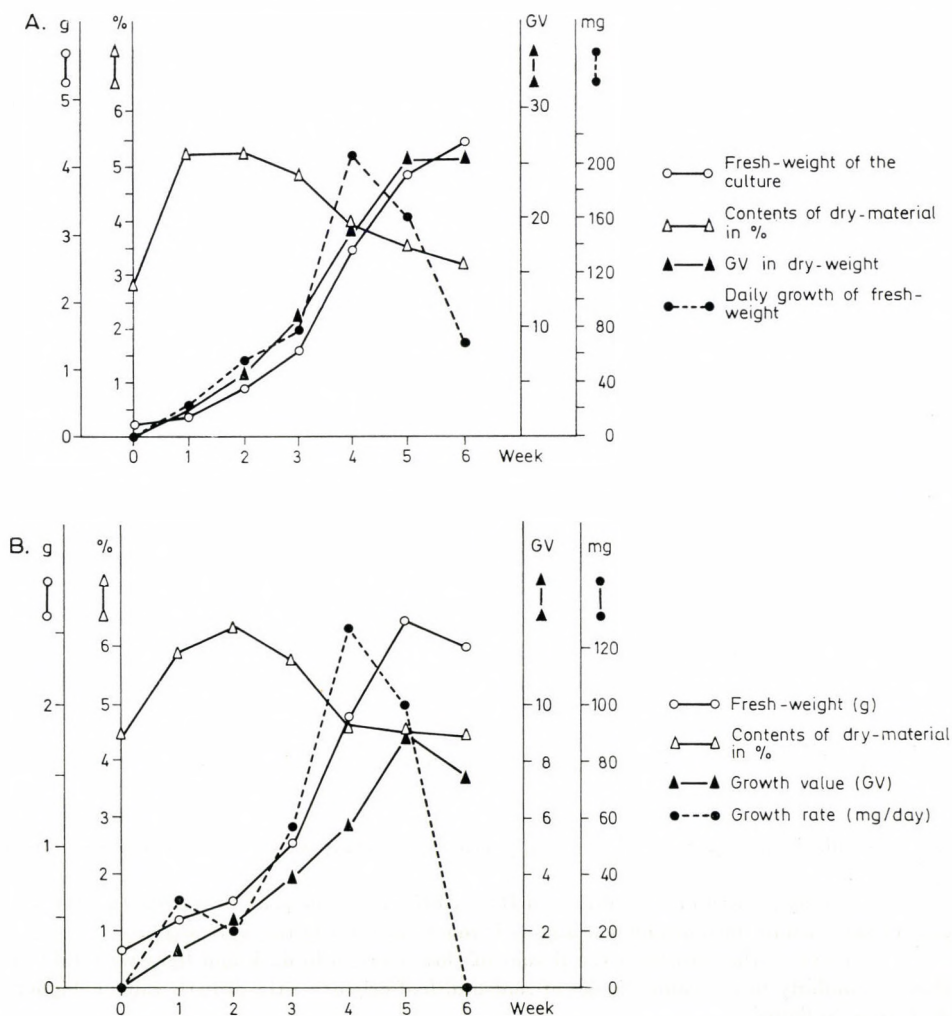
*Fig. 5.* Growth dynamics of callus tissue of ovary origin of *Datura innoxia.* — A: grown in dark; B: grown in light
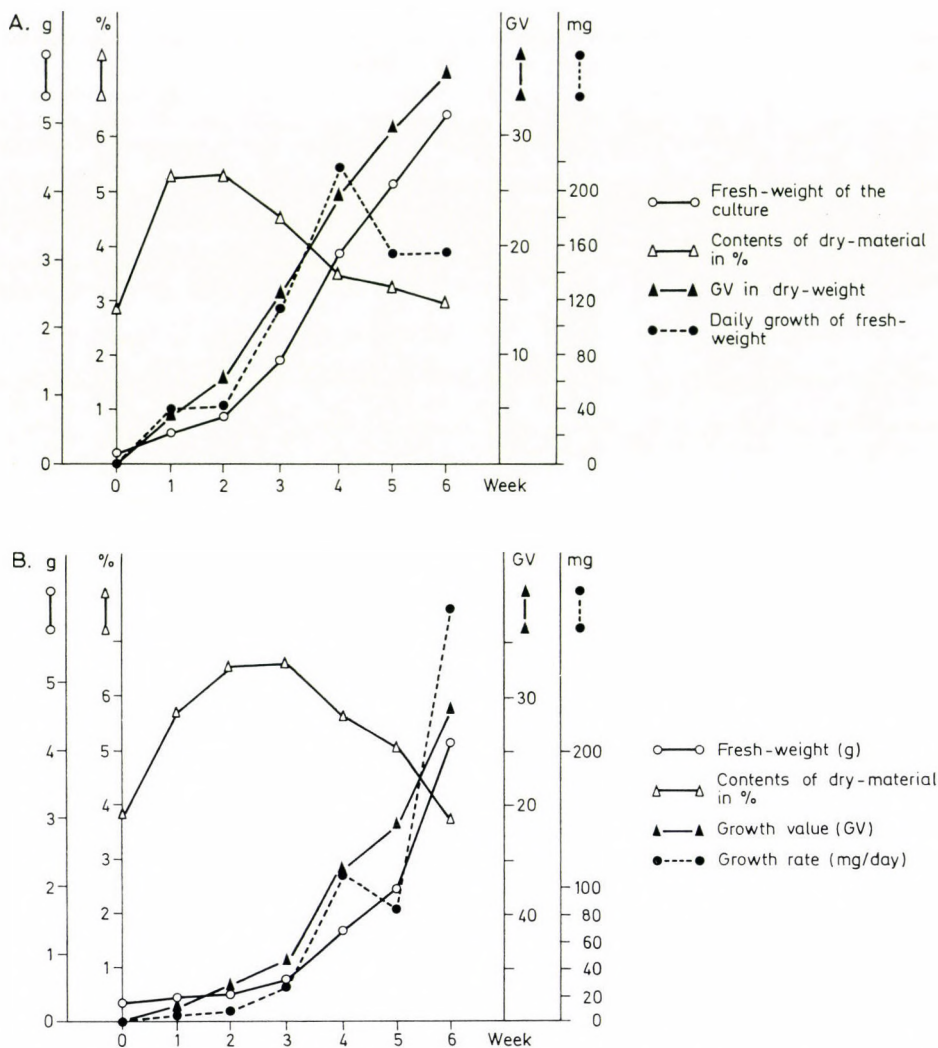
*Fig. 6.* Growth dynamics of the callus tissue of petal origin of *Datura innoxia*. — A: grown in dark; B: grown in light

(DUNG et al., in press). So we had an opportunity to compare the examinations of growth dynamics.

The daily growth of the cultures of flower origin hits the peak in the fourth week while that of the cultures of root and leaf origins is most intensive in the sixth week.

Examining the growth of the tissues of flower origin in dark and light we established that — similarly to the callus tissues of root and leaf origins — the growth value is higher in dark than in light.

It must be noted that HIRAOKA's stem cultures of *Datura innoxia* grew more intensively in light (1976).

Growing callus tissues in media without kinetin, we established that the cultures of petal origin grew slightly more intensively in this case than in the basic medium (1 mg/l of kinetin and 1 mg/l of 2,4-D) while in case of the other three cultures the growth was checked.

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# EL GÉNERO DIPLASIOLEJEUNEA EN CUBA*

D. M. REYES

INSTITUTO DE BOTANICA, ACADEMIA DE CIENCIAS DE CUBA, LA HABANA, CUBA

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After a historical account key and detailed description of Cuban *Diplasiolejeunea* species are given based mostly on own collections. Before the Author's activity only 4 species were known from the island, which number is increased to 12, including 3 species new to science: *Diplasiolejeunea pocsii* Reyes, *D. grolleana* Reyes and *D. borhidiana* Reyes. According to our present knowledge, Cuba is one of the richest areas in Diplasiolejeunea species and especially its eastern part, where the greatest number of species are concentrated, might play an important role in the evolution and speciation of the genus. Each species are figured and distribution maps are given.

## Agradecimientos

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## Introducción

La especie que representa el Lectotipo de este género es *Diplasiolejeunea pellucida* (Meissner) Schiffner = *Jungermannia pellucida* Meissner.

La duplicidad en los anfigastrios en las plantas de este género han hecho que historicamente se hayan estudiado separadas del resto de las lejeuneas, en Synopsis Hepaticarum son tratadas en una sección del género Lejeunea, la sección Duplicatae, GOTTSCHE et al. (1844–1847).

SPRUCE las plantea como un subgénero dentro del género *Lejeunea*, el subgénero *Diplasio-Lejeunea* (SPRUCE 1884), el cual es elevado al rango de género por SCHIFFNER [in ENGLER et PRANTL: Nat. Pflanz. 1/3: 121 (1893)].

Debido a la diversidad de características que presentan las especies pertenecientes a este género, SCHUSTER (1970), lo ha dividido en tres subgéneros: *Physolejeunea*, *Austrolejeuneopsis*, y *Diplasiolejeunea*.

Subgénero *Physolejeunea*. — Plantas con filidios profundamente convexos, más o menos uniformes, distantemente dispuestos dejando ver el caulidio; anfigastrios relativamente pequeños y puntiagudos; limbo del filidio con márgenes llanamente adheridos al lóbulo; lóbulos grandes con el margen superior involuto.

* Parte del tesis entitulo: Estudio taxonómico y fitogeográfico de la subfamilia mas importante de las hepáticas epífilas (Lejeuneaceae: *Cololejeuneoideae*) en Cuba.

Subgénero *Austrolejeuneopsis.* — Plantas con filidios profundamente convexos, distantemente disquestos dejando ver el caulidio; limbo del filidio con márgenes no involutas, cuando es aplanado, el contorno es más o menos encorvado.

Subgénero *Diplasiolejeunea.* — Filidios estrechamente imbricados, ocultando el caulidio; células foliares laminares, puntiagudamente dimórficas; anfigastrios grandos de segmentos redondeados.

TIXIER (1978), partiendo de especies colectadas en Madagascar, establece las secciones siguientes tomando como elementos caracteristicos del gametófito, fundamentalmente de los filídios y anfigastrios:

Sección *Pellucidae* (nom. illeg., dentro del subgénero Diplasiolejeunea Schuster), typus: *D. pellucida* (Meissn.) Schiffn.

Sección *Villaumeae*, typus: *D. villaumei* Steph.

Sección *Utriculatae*, typus: *D. utriculata* Steph.

Sección *Cornutae*, typus: *D. cornuta* Steph.

El mismo autor (TIXIER 1982) elevece al rango de especie D. pellucida var. malleiformis Evans, y describe 21 subspecies.

El género *Diplasiolejeunea* está ampliamente distribuido en las regiones tropicales del mundo. Se han descrito 49 especies, de las cuales se han synonimizado 3, y dos variedades. De las cuales 23 especies y 2 variedades están presentes en América Tropical.

## El género Diplasiolejeunea en Cuba

La presencia de este género en Cuba fue reportado por primera vez por MONTAGNE (1842), bajo el nombre de *Lejeunia unidentata* Lehmann et Lindenberg. EVANS (1912), da a conocer la presencia en Cuba de la *D. pellucida* (Meissr.) Schiffn. y aclara la identidad de *Lejeunea unidentata* reportada por MONTAGNE (1842) de Cuba con *D. rudolphiana* Steph. STEPHANI (1916) describe la especie *D. cobrensis* Gott. ex Steph., colectada en Cuba por WRIGHT.

En 1976 como resultado de la revisión de materiales colectados en Cuba, se encuentran nuevas especies del género *Diplasiolejeunea*, estas son: *D. brunnea* Stephani, *D. johnsonii* Evans, las que sumadas a las anteriores hacen un total de 6 especies de este género presentes en Cuba.

A partir de 1978 se realizan numerosas expediciones de colectas en toda Cuba conjuntamente con el Dr. Pócs encontrándose otras especies: *D. armatiloba* Stephani, *D. cavifolia* Stephani, *D. galloana* Jovet-Ast, *D. pellucida* var. *malleiformis* Evans, y tres especies, que parecen ser, nuevas para la ciencia, completando de esta forma un total de 12 especies y 1 variedad.

## Clave dicotomica para la determinacion de especies del género *Diplasiolejeunea*, presentes en Cuba

1. Plantas con el margen del filídio formado por células hialinas ........ 2
   2. Plantas pequeñas, formando parches no compactos afelpados, filídios reniformes, no adheridos al sustrato. Monoicas ................. 3
      3. Plantas cortícolas, color verde brillante cuando se colectan, blanquecinas cuando secas, diente apical maleiforme, ángulo de abertura de los segmentos del anfigastrio redondeados ........... *D. armatiloba* (1)

3. Plantas epífilas, color verde olivo cuando se colectan, pardas cuando secas, diente apical agudo, ángulo de abertura de los segmentos del anfigastrio agudo .............................. *D. brunnea* (2)

2. Plantas grandes, 17–25 mm de longitud, formando parches compactos aplanados, filídios ovados, aplanados, adheridos al sustrato. Dioicas 4

4. Plantas que forman parches con los extremos de las ramas adheridos al sustrato, diente posterior inconspicuo, papila hialina distal ... 5

5. Plantas con filídios 1–2 ocelos basales, diente apical agudo, ápice de segmentos de anfigastrios terminado en célula aguda ........... ........................................ *D. pellucida* (7)

5. Plantas con filídios sin ocelo basal, diente apical maleiforme, ápice de segmentos de anfigastrios terminado en una célula cónica ...... ................................. var. *malleiformis* (8)

4. Plantas que forman parches con ramas en toda su extensión adheridas al sustrato, carece de ocelo basal, diente apical maleiforme terminado en células hialinas, diente posterior conspicuo, papila hialina central, ápice de los segmentos agudos terminados 1–2 células hialinas puntiagudas ........................................ *D. pocsii* (11)

1. Plantas con el margen del filídio formado por células no hialinas ..... 6

6. Plantas con las ramas secundarias idénticas a la rama principal, filídios con el margen inferior revoluto .............................. 7

7. Plantas con filídios con 1–2 ocelos basales diente apical curvado, anfigastrios distantes, segmentos del anfigastrio con ápices agudos. Dioicas ....................................... *D. cobrensis* (4)

7. Plantas sin ocelos basales, diente apical terminado en dos células hialinas superpuestas, anfigastrios imbricados con el ápice de los segmentos redondeados. Monoicas ......................... *D. johnsonii* (6)

6. Plantas con filídios y anfigastrios de las ramas secundarias más pequeñas que en la rama principal, filídios con el margen inferior no revoluto 8

8. Plantas con el diente apical del lóbulo siempre agudo .......... 9

9. Plantas formando parches epífilos o cortícolas compactos, célula del ápice de los segmentos del anfigastrio redondeadas o cónicas nunca hialinas. Monoicas ........................................ 10

10. Plantas con rizidios ramificados, anfigastrios imbricados ocultando el caulicio, ápice de los segmentos de anfigastrios redondeado, diente apical agudo extendido, diente posterior inconspicuo ................................. *D. unidentata* (10)

10. Plantas con rizidios simples, anfigastrios distantes dejando ver el caulidio, ápice de los segmentos del anfigastrio agudos, diente apical agudo, muy largo, 10–13 células, oblícuo, diente posterior conspícuo generalmente curvado ......... *D. rudolphiana* (9)

9. Plantas formando parches no compactos, anfigastrios con el ápice

de los segmentos agudos terminados en 1–2 células hialinas. Dioicas ............................................ *D. galloana* (5)

8. Plantas con el diente apical del lóbulo maleiforme ............ 11

11. Plantas poco robustas, pequeñas 9–12 mm de longitud, rizidios simples, ocelos 5–7 por filídio. Ápice de los segmentos del anfigastrio agudo. Monoicas ...................... *D. cavifolia* (3)

11. Plantas robustas, grandes, 14–25 mm de longitud, ocelos ausentes ................................................ 12

12. Anfigastrios contiguos, bífidos 1/3–1/2 de su longitud, ápices de los segmentos redondeados. Rizidios ramificados. Células centrales del limbo 20–25 $\mu$m, diente posterior del lobulo conspicuo, 2–4 células de alto ...................... *D. grolleana* (12)

12. Anfigastrios distantes, bífidos 2/3–3/4 de su longitud, ápices de los segmentos agudo. Rizidios simples. Células centrales del lobulo 11–15 $\mu$m, diente posterior del limbo oculto por involución del margen libre ................... *D. borhidiana* (13)

## Descripcion de las especies Cubanas del género Diplasiolejeunea

### 1. **Diplasiolejeunea armatiloba** Stephani, Hedwigia 35: 80 (1896)

Tipo: ?

Plantas poco robustas, pequeñas 12–17 mm de longitud, 1.5 mm de ancho total de la rama principal. Color verde brillante cuando se colectan, blanquecinas cuando secas. Corticolas o epífilas, formando parches compactos, deprimidos. Ramificaciones irregulares, simples, rama secundaria idéntica a la rama principal. Rizidios simples, caedizos, poco numerosos, alargados 32–40 $\mu$m de longitud, 5–7 $\mu$m de ancho, color pardo, transparentes, formando fasciculo sobre paranfigastrio. Caulidio poco robusto 75–82 $\mu$m de ancho, sinuoso; anatomía interna formada por 7 células corticales y 3 células medulares con espesamientos intermedios en la membrana. Filídios ovado-oblongos, aplanados, o reniformes, inserción transversal, base de inserción muy breve 9–12 $\mu$m, incumbentes, imbricados hacia la cara dorsal, margen hialino formado de 2–5 estratos celulares; ápice del limbo redondeado, margen superior cóncavo, margen inferior convexo hacia la quilla, células del borde no hialino 13–15 $\times$ 13–15 $\mu$m; células centrales ligeramente más grandes que las de borde; células basales grandes y alargadas 20–25 $\times$ 47–52 $\mu$m, con trígonos y espesamientos intermedios; ocelos presentes 10–15 por filídios, dispersos, 8–11 $\times$ 22–25 $\mu$m. Lóbulo grande con relación al tamaño del filídio, hinflado, el margen libre involuto en parte, la parte no involuta extendida y adherida al limbo del filídio lo que forma un pliegue desde la base del lóbulo hasta la mitad de su longitud; quilla arqueada. Diente apical generalmente maleiforme, raras veces agudo, 3–4 células de alto, cuando el diente apical es maleiforme el ápice está formado por dos células cuadradas, o por 3–4 células, en este caso, las dos células de los extremos son agudas hialinas, cuando el diente es agudo el ápice está formado por una célula cuadrada o cónica. Diente posterior formado por 1–2 células, inconspicuo, a veces oculto. Papila hialina no observada. Anfigastrios pequeños con relación al tamaño de los filídios, ápice de los segmentos redondeado o ligeramente agudo formado por varias células o por una célula cónica; 10–12 células en la base de cada segmento, base de inserción redonda, ángulo de abertura de los segmentos redondeado; se diferencia de *D. brun-*
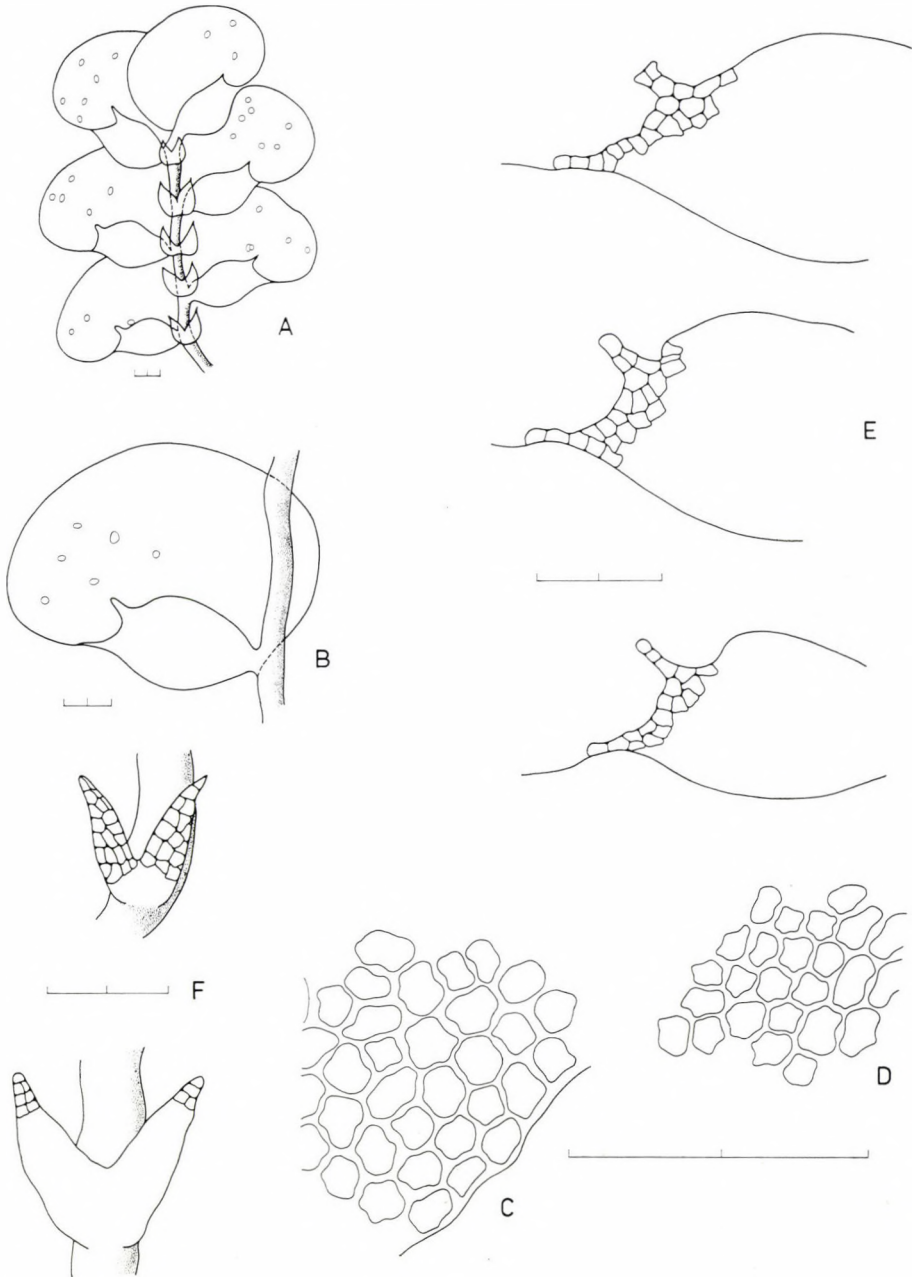
*Fig. 1. Diplasiolejeunea armatiloba* Stephani — A. Porción de la planta cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Lóbulo, diente apica F. Anfigastrio

*Fig. 2. Diplasiolejeunea armatiloba.* Distribución

*nea* Stephani en que el tamaño de los anfigastrios es diferente, y el ápice de los segmentos, que allí, son agudos. Plantas monoicas. Según STEPHANI (1916), el perianto crece en una innovación lateral; de tamaño grande 1.83 mm de alto, y 0.90 mm de ancho, ápice redondeado, bordes lisos, brácteas pequeñas lanceoladas con lóbulos grandes 1/3 del tamaño de la bráctea; brácteola pequeña, ovada, bifida 1/2 de su longitud total, ápice de los segmentos agudos, ángulo de abertura de los segmentos obtuso. Inflorescencia formada por 4–5 pares de brácteas, anteridios sésiles.

*Habitat.* — Cortícolas, ramícolas o epífilas, crecen en vegetación de pluvisilva montana. Ha sido colectada sobre ramitas hacia la parte más próxima a la base del peciolo de las hojas, en las ramas inferiores de la planta que sirve de sustrato, vegetación pluvisilva montana, clima estacional húmedo, 1100 m en La Gran Piedra.

*Material revisado.* — CUBA: Provincia Santiago de Cuba, Gran Piedra, 1100 m, col. REYES 2713 (HAC). — DOMINICA: Hepaticae dominicensis Elliottinae 1649, 16492, 16541 (G). 1074/24 (S). Le Mont Rougé, sin col. (S). — MEXICO: Chiapas, col. SHARP s/n (F).

*Distribución.* — Cuba, Guadalupe, Dominica, México, Ecuador

## 2. **Diplasiolejeunea brunnea** Stephani, Spec. Hepat. V: 922 (1916)

Tipo: Guatemala, Cobán, col. Türkheim s/n, ex hb Levier (G).

Plantas pequeñas 8–16 mm de longitud, 1.5–2 mm de ancho total de la rama principal. Color verde brillante a verde olivo cuando se colectan, blanquecinas a pardas cuando secas, a lo que deben su nombre. Ramificaciones irregulares, ramas secundarias diferentes en longitud de la rama principal, ancho total idéntica la rama principal. Rizidios transparentes, color pardo claro, 32–77 μm de longitud, 8–12 μm de ancho, numerosos, creciendo sobre paranfigastrio. Caulidio poco robusto 75–87 μm de ancho, en un corte transversal aparecen 7 células corticales y 3 células medulares con espesamientos en la membrana, células corticales 7–19 × 16 μm, células medulares 3–10 × 10 μm. Filídios ovados-oblongos, reniformes; inserción transversa, base de inserción muy corta, incumbentes, separadamente imbricadas hacia la cara dorsal; limbo del filídio de margen lisa algunas veces formados por 2–8 estratos de células hialinas, las células del borde no hialino, casi cuadradas 10–15 × 10–12 μm, con escasos trígonos y espesamientos intermedios; células centrales más grandes 17 × 15–17 μm con pocos trígonos y engrosamientos intermedios; células centrales parecidas a las del borde; células basales grandes y alargadas 27–35 × 12–20 μm, con trígonos y espesamientos intermedios. Ocelos 12–20 por filídios, dispersos por el limbo. Oleocuerpos de las células vegetativas pequeños y numerosos, fusiformes, con la superficie globulosa debido a que están formados por pequeños glóbulos; los oleocuerpos de los ocelos son grandes y poco numerosos, pero igual en forma. Lóbulo grande con relación al tamaño del filídio, hinflado, arqueado; quilla muy arqueada. Diente apical agudo formado por 3–5 células de alto, y 2–3 células en la base; ápice del diente apical formado por 1–2 células agudas. Diente posterior conspícuo, formado por 2–3 células de alto, base formada por 1–2 células, raras veces oculto por involución del margen libre del lóbulo. Papila hialina no observada. Anfigastrios pequeños con relación al tamaño de los filídios, situados separadamente en el caulidio, dejando ver parte de éste, son bífidos 3/4 de su longitud total 6–8 células en la base de los segmentos, abertura del ángulo de los segmentos agudo, ápice de los segmentos agudos, formado por 1–2 células puntiagudas, margen liso, base de inserción redonda. Plantas dioicas. Inflorescencia femenina creciendo en una pequeña innovación de una rama secundaria, brácteas y brácteolas parecidas a filídios y anfigastrios pero mas estrechos; perianto ovado-oblongo, ápice redondeado 1–2 mm de alto, 0.7–0.8 mm de ancho; arquegonio pedunculado. Inflorescencia masculina ocupando una rama secundaria, intercalar o terminal, formado por 3–4 pares de brácteas, brácteas y brácteolas aunque parecidas a filídios y anfigastrios, bien diferenciable de éstos por ser más pequeños y de lóbulos muy grandes. Presentan estas plantas numerosos propágulos disciformes, situados de forma indiscriminada sobre la cara dorsal del limbo del filidio, los filídios que llevan propágulos son idénticas a los que no los llevan; los propágulos están formados por 28 células hacia el lado izquierdo, y 27 células hacia el lado derecho, con 4 proyecciones celulares, el tamaño de los propágulos es variable.

*Habitat.* — Son plantas epífilas, crecen formando parches dispersos hacia la parte apical y central del limbo de las hojas, y especialmente hojas de palmas, cuando crecen en lugares muy húmedos y sombríos cubren casi la totalidad del limbo; han sido colectadas también sobre hojarazca, viven en vegetación de pluvisilva de montana, pluvisilva submontana y bosque nublado a diferentes altitudes.

*Material revisado.* — CUBA: Provincia Granma, subida Loma Albear 1300–1400 m, col. Pócs 9066/DB, DC (HAC, EGR). Provincia Santiago de Cuba, La Gran Piedra, 1100 m, col. Reyes s/n (HAC, EGR). Provincia Holguin, camino de Moa hacia La Melba, col. Bisse 15457/a (JE). Col. Borhidi 5961 (JE). Dos Kms N de La Melba, cerca Dos Comadres, col. Pócs y Reyes 9170/DN, CM, CN (HAC, EGR). Provincia Guantánamo, Monte Verde, col. Wright s/n (FN). Norte de Guantánamo, Cupeyal, col. Schubert. — JAMAICA: Delphin Head and vicinity, epífilo, col. Britton 2308 (JE). — TRINIDAD: Valencia, Toco Road,
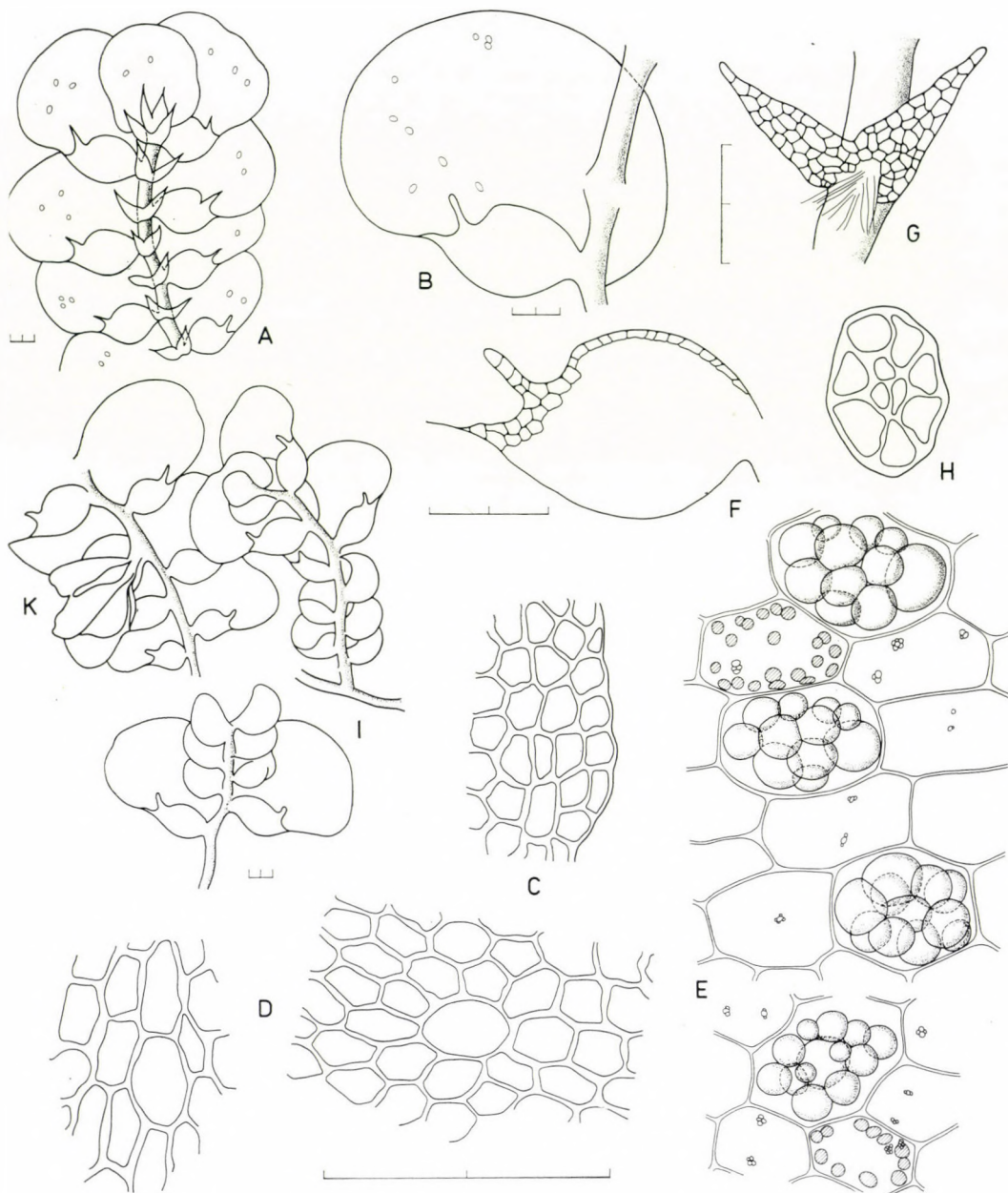
*Fig. 3. Diplasiolejeunea brunnea* Stephani — A. Porción de la planta cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro y de la base del filidio. E. Oleocuerpos. F. Lóbulo. G. Anfigastrio. H. Anatomía del caulidio. I. Inflorescencias femenina y masculina

*Fig. 4. Diplasiolejeunea brunnea* Stephani. Distribución

col. BRITTON 1838, 1846, 1847 (FH). — GUATEMALA: Sin localidad, col. TÜRCKHEIM 5826, ex hb. LEVIER (G). Laguna Sapalá, Alta Verapaz, col. STEYERMARK 44935 (F). — HONDURAS: Sin localidad, sobre hojas de piper, col. STANDLEY 18594 (FH). — COSTA RICA: San Domingo de Golfo Dulce, col. POTTIER 15603 (NY) Valle Rio Luis, col. TONDUZ 15566, 15569, 6229 (FH). — VENEZUELA: La Guaira, sin col. 1074/14 (S). — ECUADOR: Santiago Zamora, col. MÉNDEZ 1074/2 (S). Provincia Los Rios Hacienda Clementina, sin colector 1074/3 (S). Zamora Chinchipe, sin colector 1074/6, 9, 10, 11 (S). Provincia Napo Pastaza, sin colector 1074/8, 22 (S). Provincia Esmeraldas sin colector 1074/7, 12, 13 (S). — PERU: Departamento de Junin, along Rio Perené near Hacienda 3 Colonia Perené, 600 m, col. KILLIP and SMITH 25167 (NY). Tarapoto, sin colector 609 (FH). — BOLIVIA: Sin localidad, col. HOLMES s/n (NY). Epífila, col. HERZOG 4706 (FH). — BRAZIL: Sao Paolo, sin colector 1074/23 (S).

*Distribución.* — Cuba, Jamaica, Trinidad, México, Guatemala, Honduras, Costa Rica, Venezuela, Ecuador, Peru, Bolivia, Brazil

## 3. **Diplasiolejeunea cavifolia** Stephani, Bot. Jahrb. Syst. 20: 318 (1895), Spec. Hepat. 5: 918 (1916)

Syn.: *Lejeunea cavifolia* Stephani, Bot. Jahrb. 7: 89 (1886)

*Diplasiolejeunea brachyclada* Evans, Bull. Torrey Bot. Club 39: 216 (1912)
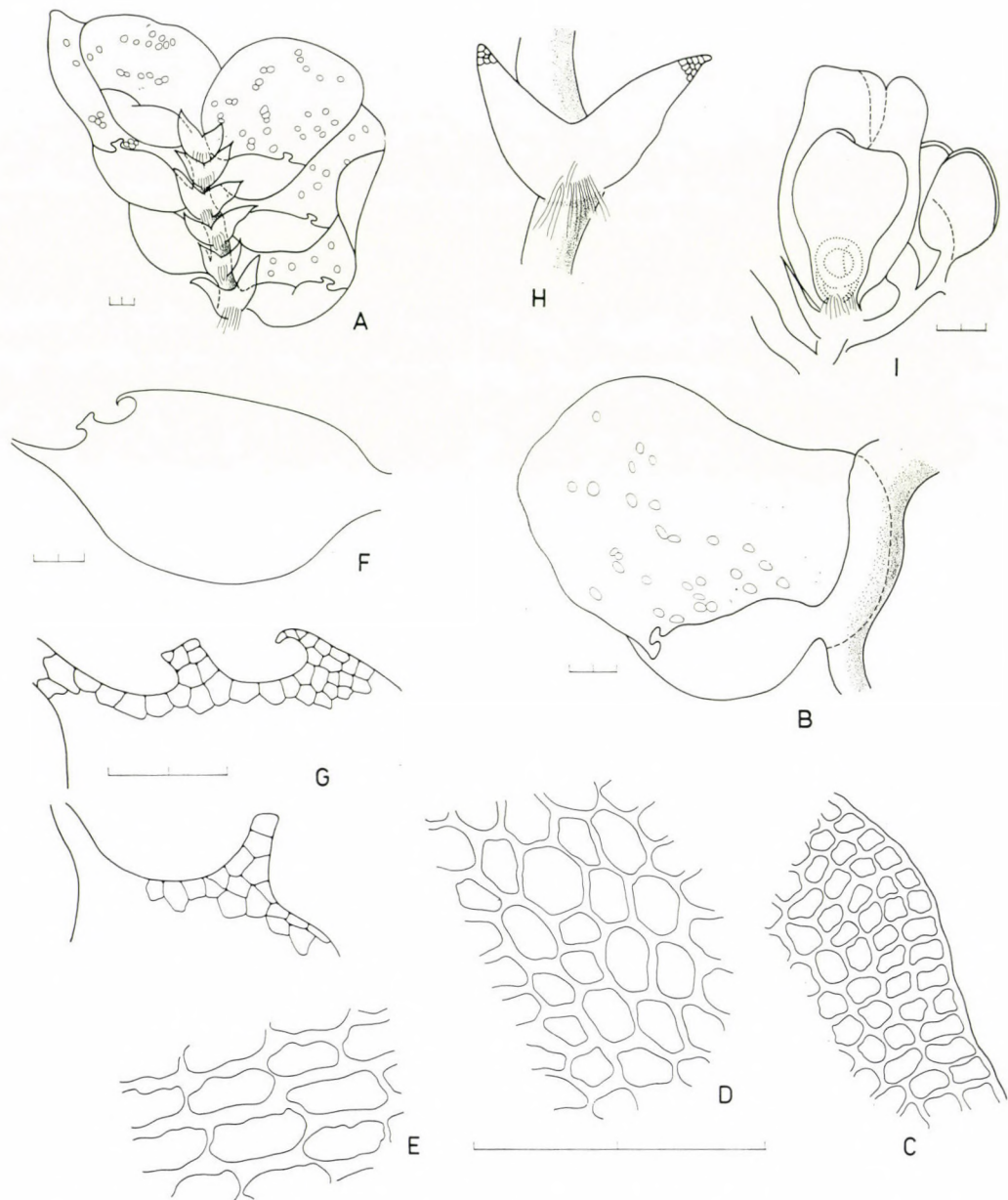
*Fig. 5. Diplasiolejeunea cavifolia* Stephani — A. Porción de la planta cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Células de la base del filidio. F. Lóbulo. G. Diente apica' diente posterior. H. Anfigastrio. I. Rama autoica

*Diplasiolejeunea javanica* Stephani, Spec. Hepat. 5: 928 (1916)
*Diplasiolejeunea vanden-bergheni* Grolle, Rev. Bryol. Lichén. 29: 208 (1969)
Tipo: São Thomé, Mt. Caffé, 700 m, col. MOLLER 7a (G).

Plantas de mediano tamaño 15–20 mm de longitud, 1.5–2 mm de ancho total de la rama principal. Epífilas o corticolas. Color verde brillante cuando se colectan, blanquecinas o pardas cuando secas. Cuando son epífilas crecen formando parches no compactos, dispersos; cuando son corticolas crecen formando parches compactos, numerosos. Ramificaciones irregulares distantes, las ramas secondarias diferentes a la rama principal en cuanto a longitud y tamaño de los filidios y anfigastrios. Rizidios numerosos, 0.1 mm de longitud, pardos, transparentes, simples, creciendo en fascículo denso sobre paranfigastrio. Caulidio robusto 0.8–1 mm de ancho, a veces sinuoso; células corticales isodiamétricas, grandes, alargadas $7\text{–}25 \times 19$ µm; células medulares cortas, pequeñas $3\text{–}19 \times 13$ µm. Filídios ovados, de inserción casi transversa, base de inserción muy corta 0.9–1.1 mm, incumbentes, subimbricados a imbricados hacia la cara dorsal, margen liso, ápice ovado, margen superior a veces revoluto, células del borde $14\text{–}20 \times 17\text{–}22$ µm, células centrales $15\text{–}20 \times 20\text{–}27$ µm con escasos trígonos y espesamientos intermedios; células basales más grandes y alargadas $17\text{–}22 \times 18\text{–}27$ µm con trígonos y espesamientos intermedios. Ocelos numerosos 20–28 por filídios, a veces agrupados, $18\text{–}23 \times 19\text{–}26$ µm, membranas sin trígonos ni engrosamientos intermedios. Lóbulo grande, con relación al tamaño del filídio, hinflado, margen libre involuto en parte; quilla formando un ángulo agudo con el margen inferior del limbo del filidio; diente apical maleiforme, a veces ligeramente agudo, disquesto oblícuamente, 4–6 células de alto, 2–3 células en la base; diente posterior conspícuo, 2–3 células de alto, 2 células en la base, a veces oculto por la involución del margen libre, el diente apical y el diente posterior forman un ángulo abierto redondeado, típico de esta especie. Papila hialina central con relación a la base del diente apical. Anfigastrios distantes, dejando ver parte del caulidio, bífidos hasta 3/4 de su longitud total, ápice de los segmentos terminado en 1–2 células apiculadas, ángulo de separación de los segmentos muy abierto; 7 células en la base de cada segmento, bordes lisos, base de inserción al caulidio redondeada. Plantas autoicas. Inflorescencia femenina ocupando una pequeña innovación en una rama secundaria; brácteas y brácteolas muy parecidas a filidios y anfigastrios, pero de menor tamaño; perianto de bordes lisos, ápice redondeado, 1–1.5 mm de alto, y 0.5–0.8 mm de ancho, arquegonio sésil. Inflorescencia masculina formada por 3–5 pares de brácteas; brácteas y brácteolas muy parecidas a filidios y anfigastrios de menor tamaño y lóbulos muy grandes; anteridios sésiles.

*Habitat.* — Epífilos, ramícolas o cortícolas, crecen formando parches sobre la superficie del limbo de las hojas, sobre ramas jóvenes, o sobre corteza de plantas que viven en pluvisilvas, llanas a orillas de ríos, pluvisilvas montanas, pluvisilvas altimontanas, o bosques nublados, en tipos de bioclimas eutermáxérico en la región de Moa, estacional húmedo en la región de Moa, también, y en la Sierra Maestra, y en clima eumesaxérico en la Sierra Maestra.

*Material revisado.* — CUBA: Provincia Santiago de Cuba, Pico Turquino, Sierra Maestra 1700–1750 m, epífilas, col. BORHIDI, MUÑÍZ et VÁZQUEZ 5842 (JE). El Uvero, Sierra Maestra camino de la costa al S del Manguito 400–600 m, col. BISSE et LIPPOLD 14479 (JE). Provincia Holguín, Cuchillas de Moa en pluvisilva llana del valle Rio Jaguaní 150 m, col. PÓCS y REYES 9169/BB (HAC, EGR). La Melba falda E de la Sierra de Moa 800–1000 m, col. BISSE et LIPPOLD 11163/b (JE). — JAMAICA: Sin localidad, col. EVANS, cortícola, 25505 (FH). — PUERTO RICO: Monte Cerrote near Adjuntas 900–1050 m, col. BRITTON et STEWARDSON 5452 (NY). Mt. Luquillo near El Yunque, col. EVANS 24,127 (NY). — DOMINICA: Hepaticae Dominicensis Elliottionae 16521 (G). — MARTINICA: Sin localidad, sin colector 012021 (G). — GUATEMALA: Alta Verapaz, supra Cobán 1550 m, col. TÜRCKHEIM 5074 (FI). Se Tactic Dpt Alta Verapaz 500 m, col. STANDLEY 7005 (F). Alta Verapaz 350 m, col. TÜRCKHEIM 5068b (FI). Alta Verapaz 1260–1440 m, col. STANDLEY 69372 (F, NY). Sin localidad sin colector 16523, 16524 (G). — COSTA RICA: Monte Verde sobre hojas de naranja y grifus, col. JAMES s/n (F). — VENEZUELA: Caracas prov. 4000 m, col. FUNCK et SCHLIM 387 (NY). — SURINAME:
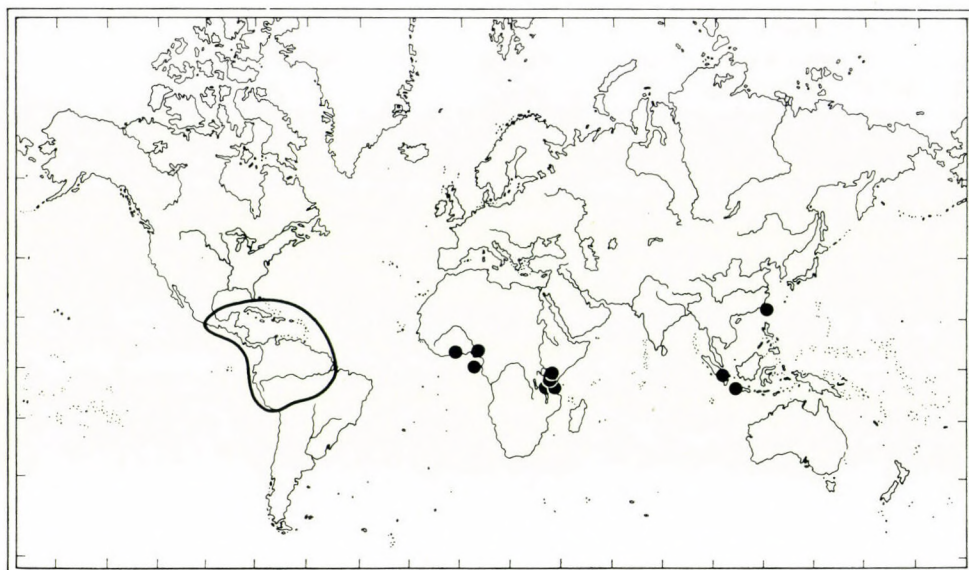
*Fig. 6. Diplasiolejeunea cavifolia* Stephani. Distribución

Sin localidad, col. SURINGAR 4744 (L). — BRAZIL: Alto Serra, São Paolo Estación biológica, col. HOEHNE 1002 (JE). Santa Catharina, col. PABST 315/a (FH). Sin localidad, sin colector 012018 (G).

*Distribución.* — Cuba, Jamaica, Puerto Rico, Dominica, Martinica, Guadalupe, Trinidad, México, Guatemala, Costa Rica, Venezuela, Suriname, Brazil, Ecuador, Java, Sumatra, Formosa, São Thomé, Nigeria, Ghana, Kenya, Tanzania, Zaïre, Mauritius

## 4. **Diplasiolejeunea cobrensis** Gottsche ex Stephani, Spec. Hepat. 5: 923 (1916)

Tipo: Cuba, El Cobre, col. WRIGHT 1173 (G);

Plantas de pequeño tamaño, con relación a otras especies de este mismo género, 5 mm de longitud. Color pardo oscuro cuando secas. Epífilas asociada a otras hepáticas. Ramificaciones irregulares, ramas secondarias idénticas a la rama principal. Caulidio robusto, extendido. Filidios ovados-oblongos, inserción transversal, base de inserción muy corta, apretadamente imbricados hacía la cara dorsal, bordes ligeramente crenulados, ápice redondeado, margen inferior revoluto, células del borde casi cuadradas y pequeñas $18 \times 18$ $\mu$m; células centrales ligeramente mayores; células basales grandes y alargadas $18 \times 36$ $\mu$m, con trigonos grandes y espesamientos intermedios; ocelos 13–18 por filidio, dispersos, sin trigonos ni espesamientos intermedios; ocelo basal constante, grande, $27 \times 54$ $\mu$m. Lóbulo grande con relación al tamaño del filidio, fusiforme, hinflado, margen libre involuto; quilla ligeramente arqueada, cónica, no papilosa; diente apical ligeramente agudo, claramente curvado, 2–3 células de alto, sin células superpuestas en el ápice, 2–3 células en la base; diente posterior inconspicuo, oculto. Anfigastrios muy pequeños con relación al tamano de los filidios, profundamente bífidos 3/4 de su longitud total, 2 células en la base de cada segmento, ápice de los segmentos terminado en 1 célula redondeada, ángulo de abertura de los segmentos ligeramente aguda, base de inserción recta, paranfigastrio muy breve, las células del anfigastrio con trigonos y espesamientos intermedios escasos. Plantas dioicas ? Inflorescencia femenina creciendo en innovación lateral de la rama principal, brácteas y brácteolas muy parecidas a los
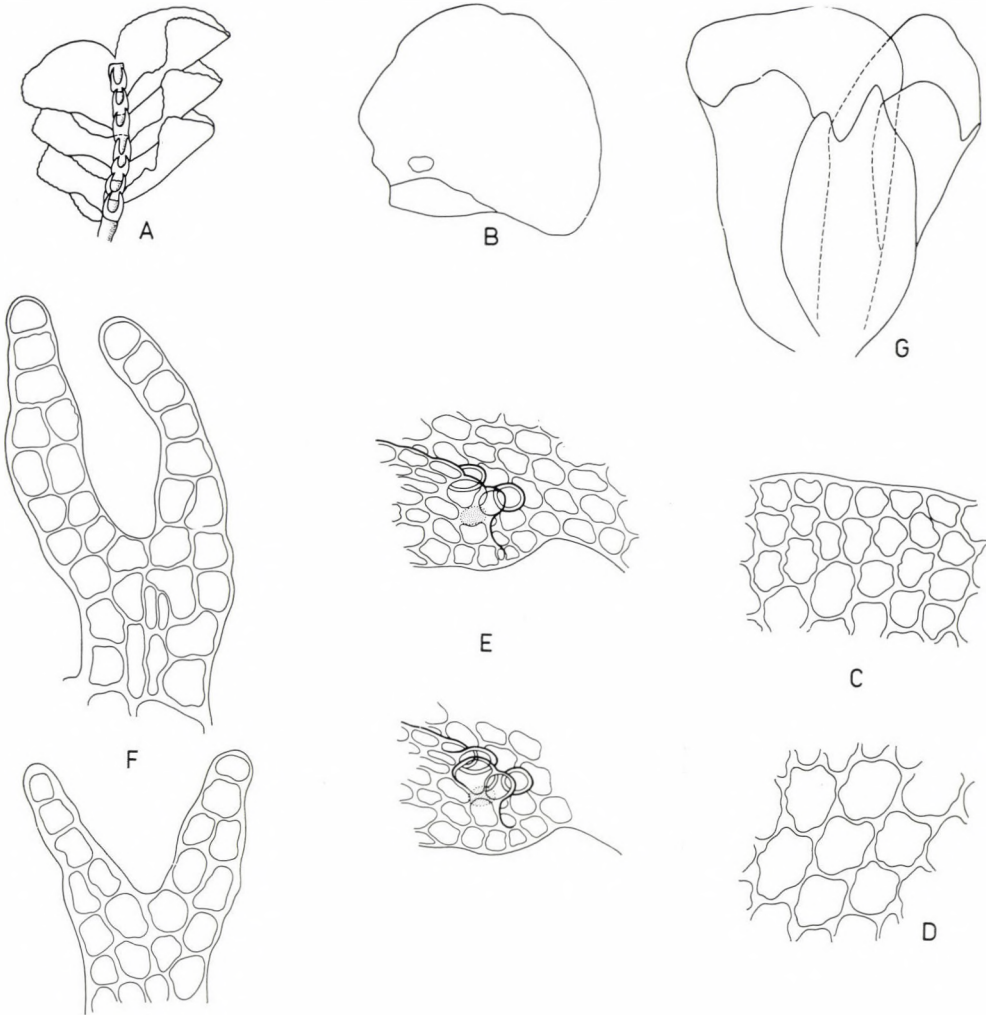
*Fig. 7. Diplasiolejeunea cobrensis* Gottsche ex Stephani — A. Porción de la planta, vista ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Diente apical y diente posterior. F. Anfigastrios. G. Perianto

filidios y anfigastrios pero de menor tamaño. Perianto alargado 1–2 mm de alto, y 0.5–1 mm de ancho, ápice redondeado, no alado.

*Habitat.* — Epífilas formando parches dispersos y comprimidos entre otras hepáticas.

*Material revisado.* — CUBA: Provincia de Oriente (actualmente Santiago de Cuba), región del Cobre, col. Wright 16495 (G) (Holotypus).

*Distribución.* — Cuba
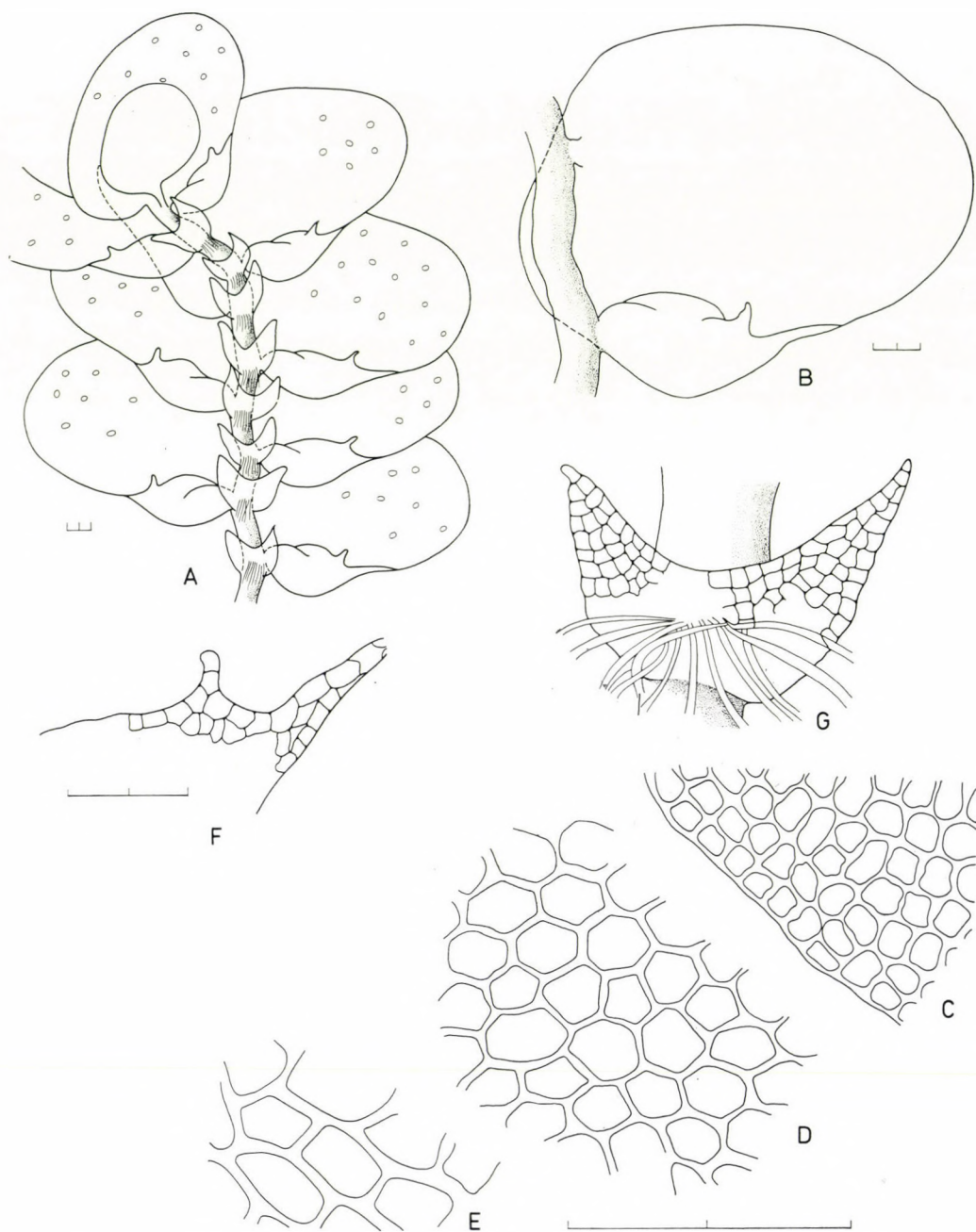
*Fig. 8. Diplasiolejeunea galloana* Jovet-Ast — A. Porción de la planta, cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Células de la base del filidio. F. Diente apical. G. Anfigastrio

## 5. **Diplasiolejeunea galloana** Jovet-Ast, Rev. Bryol. Lichen. 25: 277 (1956)

Tipo: Guadalupe.

Plantas pequeñas con relación a otras especies del género 9–12 mm de longitud, 2 mm de ancho total de la rama principal. Color verde brillante cuando se colectan, blanquecinas cuando secas. Epífilas formando parches aplanados, dispersos. Ramificaciones irregulares, distantes; ramas secundarias idénticas a la rama principal. Rizidios numerosos, 0.1 mm de longitud, transparentes, crecen en fascículo sobre paranfigastrio. Caulidio robusto, sinuoso, según Bischler (1961), en un corte transversal está formado por 7 células corticales grandes y alargadas 7–19 × 16 $\mu$m, y por 3 células medulares cortas y pequeñas 3–16 × 11 $\mu$m, ocupando la porción central, todas con espesamientos en las membranas. Filidios ovados, de inserción transversal, base de inserción breve 35–45 $\mu$m, incumbentes, imbricadas a subimbricadas por la cara dorsal, margen liso, ápice redondeado, ligeramente convexo en el margen inferior; células del borde casi cuadradas, pequeñas 10–15 × 5–7 $\mu$m, células centrales ligeramente mayores; células basales grandes y alargadas 16–18 × 21–26 $\mu$m, a menudo trígonos y espesamientos intermedios; ocelos poco numerosos 5–7 por filidio, no siempre presentes, dispersos

*Fig. 9. Diplasiolejeunea galloana* Jovet-Ast. Distribución

12–15×18–22 μm, carecen de trígonos y espesamientos intermedios. Lóbulo de mediano tamaño con relación al tamaño del filidio, 0.4–0.5 mm; quilla arqueada formando una línea continua con el margen inferior del filidio, margen libre involuto; diente apical agudo, terminado en una célula cónica o redondeada, ápice del diente apical no agudo, 3–7 células de alto, 2–3 células en la base; diente posterior conspícuo, oculto por involución del margen libre; papila hialina central con relación a la base del diente apical. Anfigastrios pequeños con relación al tamaño del filidio, bífidos 1/2 de su longitud total, ángulo de abertura de los segmentos redondeado, 6–7 células en la base de cada segmento, ápice de los segmentos apiculado, terminados en una célula aguda hialina, bordes lisos, base de inserción al caulidio redondeada. Plantas dioicas. Inflorescencia femenina ocupando una innovación corta, en la rama principal o en una rama secundaria, brácteas y bracteolas parecidas a filidios y anfigastrios pero más estrechas. Perianto según Jovet-Ast (1956), alargado 0.6–0.8 mm de longitud, 0.3–0.4 mm de ancho, bordes lisos, ápice redondeado. Esporas 35–50 μm.

*Habitat.* — Epífilos formando parches poco densos, dispersos, comprimidos, creciendo en toda la superficie del limbo de hojas de plantas que crecen en vegetación tipo bosque nublado en bioclima estacional húmedo de la Gran Piedra.

*Material revisado.* — CUBA: Provincia Santiago de Cuba, Gran Piedra Finca Isabelica 1130 m monte nublado, epífila, col. Pócs, Reyes y Duanys 9112/BS (HAC, EGR). — HONDURAS: Lancetilla Valley near Tela Dpt Atlantida 200–600 m, col. Standley 56752, 56876 (JE). — COSTA RICA: Provincia Heredia 2000 m, col. Standley 49709a (JE). — COLOMBIA: Cordilleras on Siparuna, Dpt Santander Mt. San Martín near Charta 2300–2500 m, col. Killip s/n (JE). — ECUADOR: Provincia de Pichinche, col. Asplund s/n (JE). — PERU: Sin localidad, sin colector 1074/15 (S). — BRAZIL: Sin localidad, sin colector 1074/16 (S).

*Distribución.* — Cuba, Guadalupe, Honduras, Costa Rica, Colombia, Suriname, Guyana Francesa, Ecuador, Peru, Brazil

## 6. **Diplasiolejeunea johnsonii** Evans, Bull. Torrey Bot. 39: 603 (1912)

Tipo: Jamaica, Cinchona, IV 1903, col. Johnson 14. (YU).

Plantas grandes 15–29 mm de longitud, 2–2.5 de ancho total en la rama principal. Epífilas, ramícolas o cortícolas. Verde olivo cuando se colectan, pardas cuando secas. Forman parches aplanados, compactos y numerosos. Ramificaciones irregulares, ramas secundarias idénticas a la rama principal. Rizidios numerosos, efímeros, formando fascículo sobre paranfigastrio. Caulidio robusto 187 μm de ancho, formado por 7 células corticales largas y grandes 17–30×18–20 μm; células medulares cortas y pequeñas 8–15×11–13 μm, ambas con espesamientos en la membrana. Filidios ovado-orbiculares, inserción casi transversal, base de inserción muy breve; incumbentes, apretadamente imbricados hacia la cara dorsal, margen liso, ápice redondeado, margen inferior revoluto; células del borde 17–22×15–17 μm, con escasos trígonos y espesamientos intermedios; células centrales 20–25×17–22 μm con pocos trígonos y espesamientos intermedios; células basales más grandes y alargadas 25–30×17–25 μm con trígonos y espesamientos intermedios; ocelos 15–25 por filidios, 27–32×32–37 μm, membranas sin trígonos ni espesamientos intermedios, dispersos. En material fresco aparecen oleocuerpos en las células foliares y en los ocelos, de pequeño tamaño en las células normales, grandes en los ocelos, formados por masas, aparentemente, por superposición de glóbulos redondeados y brillantes. Lóbulo grande, hinflado; quilla arqueada formando una linea contínua con el margen revoluto del filidio; diente apical agudo, esparcido oblícuamente, con el ápice formado por 1–2 células cónicas hialinas superpuestas, 3–5 células de alto, 2–4 células en la base diente posterior inconspícuo, formado por 1–2 células, a veces es una simple crenulación, otras veces reforzado por una célula coalescente, en algunas especies, colectadas en Cuba, se observa todo el margen libre ligeramente dentado, por prolongaciones celulares; papila hialina central con relación a la base del diente apical, en el ejemplar descrito por Evans (1912),
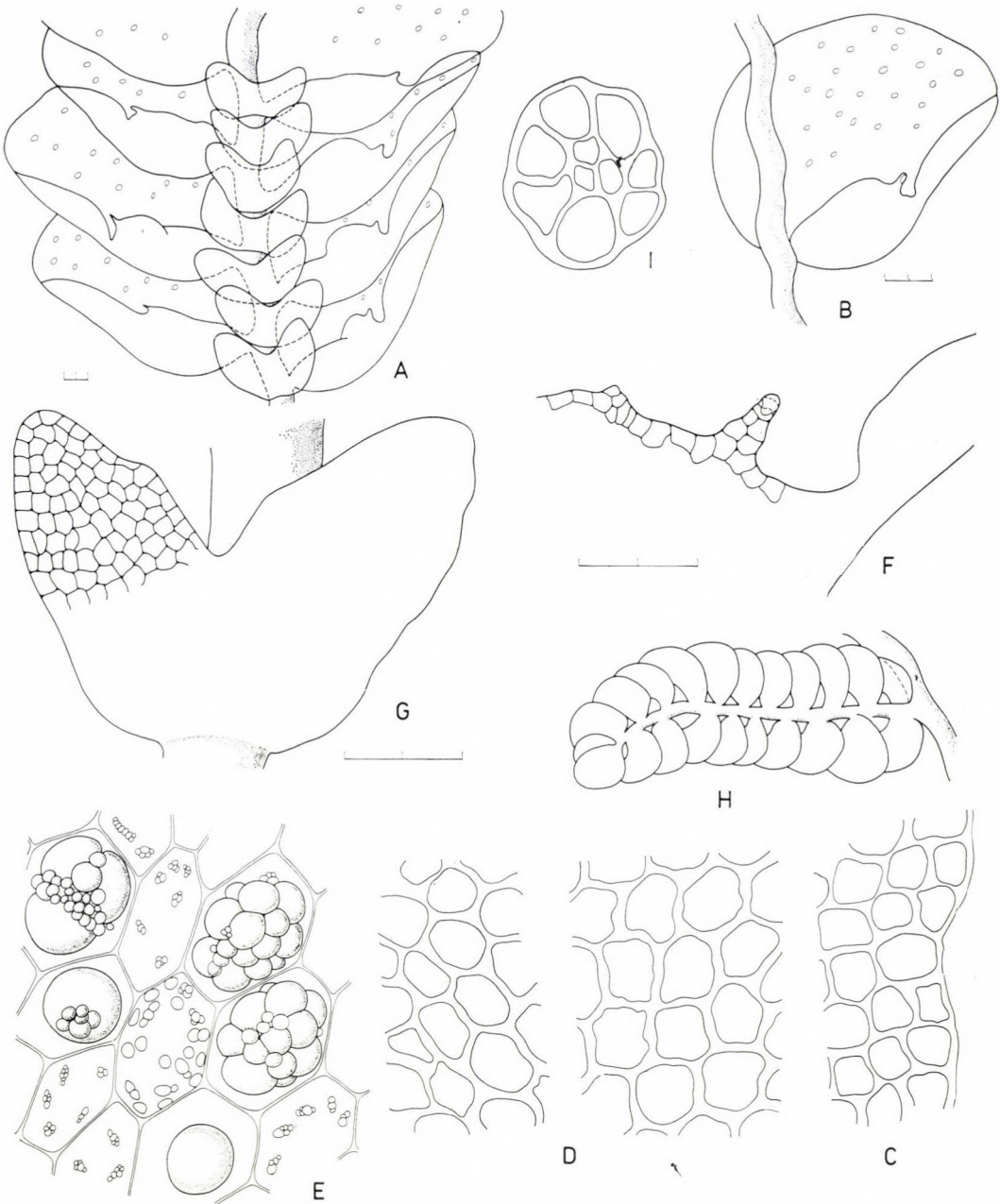
*Fig. 10. Diplasiolejeunea johnsonii* Evans — A. Porción de la planta, cara ventral. B. Filidio. C. Células borde del filidio. D. Células centro del filidio. E. Oleocuerpos. F. Diente apical y diente posterior. G. Anfigastrio. H. Inflorescencia masculina. I. Anatomía del caulidio

ocupa una posición distal. Anfigastrios imbricados, bífidos 1/2 de su longitud total, 14–20 células en la base de cada segmento; ángulo de abertura de los segmentos redondeado; ápice de los segmentos redondeados, bordes lisos. Plantas autoicas. Inflorescencia femenina según Evans (1912), naciendo en una pequeña innovación en la rama principal, 1–2 inflorescencias por rama; perianto oblongo-ovado 1.1 mm de largo, 0.6 mm de ancho, ligeramento crenulado en sus bordes, cinco quillas, ápice con un corto pico. Inflorescencia masculina en una pequeña innovación en la rama principal, formada por 8–10 pares de brácteas.

*Habitat.* — Epífilas, ramícolas o cortícolas es la especie de este género, presente en Cuba, que alcanza mayor tamaño y que forma parches más compactos, grandes y numerosos. Las especies epífilas crecen hacia la parte inferior y el pecíolo de las hojas; las especies cortícolas muestran preferencia por la corteza de Pinus sp., crecen en vegetación de pluvisilva submontana, pluvisilva montana y monte nublado, siempre sobre los 700 m de latitud; en bioclima eutermaxerico en la región de Moa, húmedo tropical de la Sierra Maestra y Gran Piedra, y en eumesaxerico de la Sierra Maestra.

*Material revisado.* — CUBA: Provincia de Sancti Spirítus, SE de Topes de Collantes 700 m, epífilos, col. Pócs y Borhidi 9007/A (HAC, EGR). Pico Potrerillo 870–970 m, ramícola,

*Fig. 11. Diplasiolejeunea johnsonii* Evans. Distribución

col. Pócs y Borhidi 9011/g (HAC, EGR). Provincia de Santiago de Cuba, Pico Suecia Sierra Maestra 1700–1750 m, ramícolas, col. Borhidi, Muñíz y Vázquez 5841 (HAC, EGR). Loma La Francia, Sierra Maestra 800–1000 m, col. Bisse et Lippold 14410 (JE). La Gran Piedra, pinares de la cima 1130 m, cortícolas, col. Pócs y Reyes 9048/G (HAC, EGR) La Gran Piedra 1130 m, epífilas, col. Pócs, Reyes y Duanys 9112/CC (HAC, EGR). Finca Isabelica sobre frutales viejos 1180 m, ramícolas, col. Pócs, Reyes y Caluff 9210/E (HAC, EGR). Sierra de La Gran Piedra, Pico Kentucky 1050 m, col. Pócs, Reyes y Caluff 9207/BO (HAC, EGR). Provincia Guantánamo, Reserva natural Cupeyal, ramícola y cortícola, col. Reyes 1105 (HAC, EGR). Sin localidad, col. Hioram 11721, 12405 (HAC, EGR). — JAMAICA: Sin localidad, sin colector 25505/b (FH).

*Distribución.* — Cuba, Jamaica

## 7. **Diplasiolejeunea pellucida** (Meissner emend. Evans) Schiffner, in Engler et Prantl, Natürl. Pflanzenfam. 1/3: 121 (1893)

Syn.: *Jungermannia pellucida* Meissner, Sprengel in Linnaeus, Syst. Veg. 16, 42: 325 (1827)
*Lejeunea ocellulata* Nees et Mont. in Mont., Ann. Sci. Nat. Bot. II, 19: 264 (1843)
*Lejeunea pellucida* Meissner Gottsche et al., Syn. Hep.: 393 (1845), Spruce, Trans. Proc. Bot. Soc. Edinburgh 15: 302 (1884)

Plantas de mediano tamaño 11–15 mm de longitud, 1.5–2 mm de ancho en la rama principal. Color verde brillante cuando se colectan, amarillentas o ligeramente pardas cuando secas. Forma parches no compactos, afelpados, el extremo de las ramas adheridos al sustrato. Ramificación regular, distante; ramas secundarias idénticas a la rama principal. Rizidios numerosos, 120 μm de longitud, finos 2–5 μm de ancho, incoloros, transparentes, formando fascículo sobre paranfigastrio. Caulidio robusto 83–87 μm de ancho, formado por 7 células corticales grandes y alargadas 7–16×11 μm, 3 células medulares cortas y pequeñas 3–14× 9–11 μm, ambas con espesamientos en la membrana. Filidios ovados, inserción transversal, base de inserción muy corta 30–45 μm, incumbentes, distantemente imbricadas hacia la cara dorsal, margen formado por células hialinas, margen inferior y superior con 2–4 estratos de células hialinas, ápice 6–8 estratos celulares hialinos; células del borde casi cuadradas 5–8× 4–6 μm con escasos trígonos y engrosamientos en la membrana; células centrales ligeramente mayores que las del borde; células basales grandes y alargadas 13–18×6–7 μm con trígonos y espesamientos en las membranas. Ocelos 16–20 por filidio, dispersos 10–15×8–10 μm, sin trígonos ni denticiones intermedias, en ocasiones agrupados. Lóbulo grande, hinflado; quilla arqueada, diente apical agudo, oblicuamente esparcido, 3–5 células de alto, 2–3 células en la base: diente posterior inconspícuo, 1–2 células de alto, a veces oculto por involución del margen libre, papila hialina distal con relación a la base del diente apical. Anfigastrios distantes, dejando ver en parte el caulidio, bífidos 3/4 de su longitud total, ápice de los segmentos agudo terminado en 1–2 células apiculadas, 12–15 células en la base de cada segmento, ángulo de abertura de los segmentos redondeada, margen entero, base de inserción al caulidio redondeada. Plantas dioicas. Inflorescencia femenina en una pequeña innovación de la rama secundaria o en la rama principal, terminal o intercalar; perianto 1–2 mm de alto, 0.5 mm de ancho, de bordes ligeramente crenulado, ápice redondeado; arquegonio sésil. Hacia la cara dorsal de los filidios más viejos aparecen numerosos propágulos disciformes, situados de forma indiscrimada en toda la superficie del filidio.

*Habitat.* — Epífilos crecen formando parches dispersos no compactos, los extremos de las ramas adheridos al sustrato, el resto afelpados, crecen en toda la superficie del limbo de las hojas que le sirven de sustrato que viven en vegetación de pluvisilva montana en bioclima estacional húmedo de la Sierra Maestra, y Gran Piedra; pluvisilva montana en bioclima hipotermaxerico de Baracoa, y en bosque nublado con bioclima tipo eumesaxerico de la Sierra Maestra.
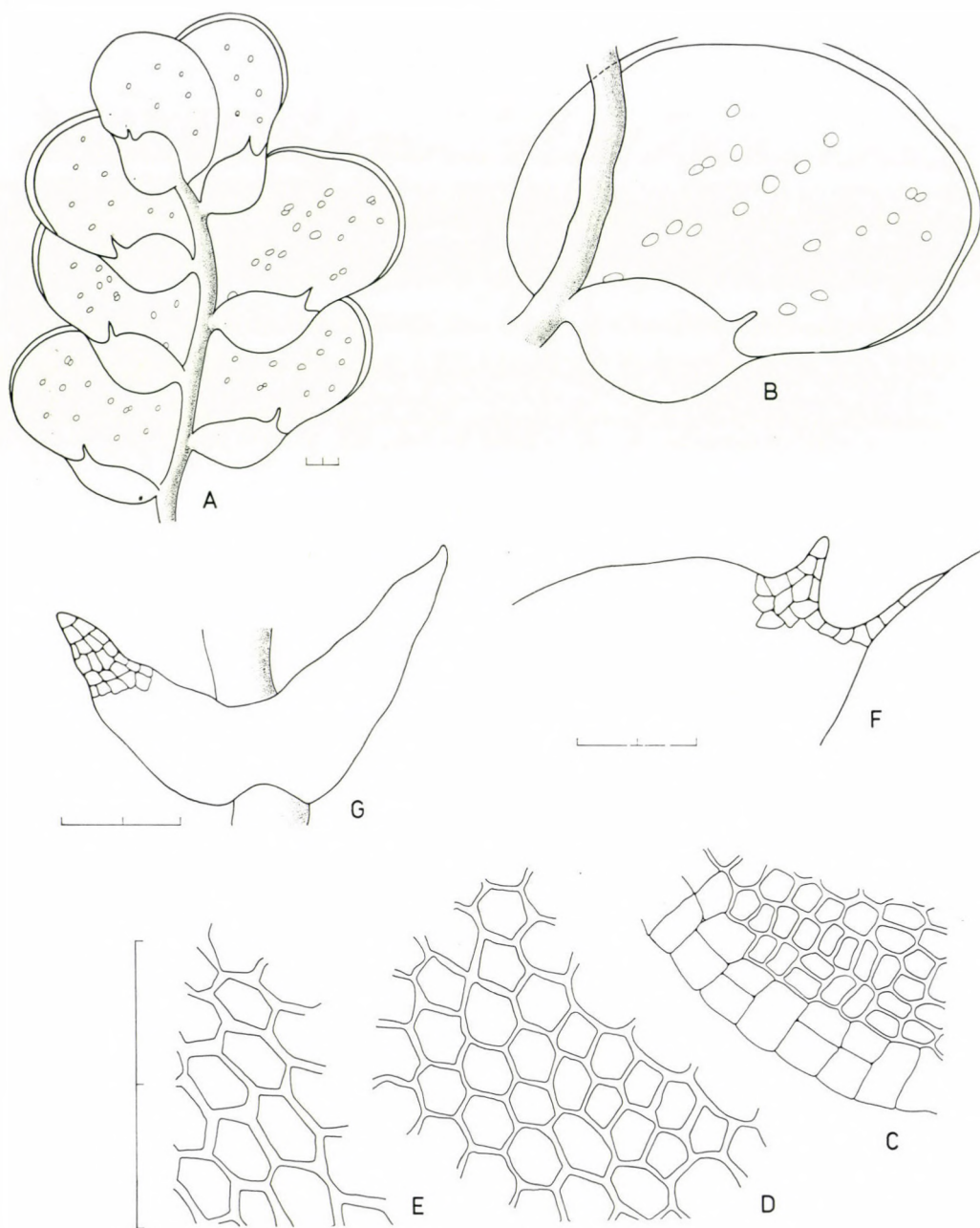
*Fig. 12. Diplasiolejeunea pellucida* (Meissner) Schiffner — A. Porción de la planta, cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Células de la base del filidio. F. Lóbulo. G. Anfigastrio

*Material revisado.* — CUBA: Provincia Sancti Spíritus, Trinidad Mt., col. BRITTON 5279, 5118 (NY). Provincia Granma, cresta E pico Palma Mocha, epífilo, col. PÓCS y DUANYS 9081/AH (HAC, EGR). Provincia Santiago de Cuba, Pico Suecia Sierra Maestra 1700–1750 m, epífilos, col. BORHIDI, MUÑÍZ y VÁZQUEZ 5839 (HAC, EGR, JE). Paso de las Angustias 1700 m, col. BORHIDI 6300 (EGR). La Gran Piedra 1130 m, epífilos, col. PÓCS, REYES y DUANYS 9012/BB, BR, 9007/S (HAC, EGR). Provincia Guantánamo, cima Yunque de Baracoa 450–540 m, epífilos, col. PÓCS y REYES 9064/BF (HAC, EGR). Sin localidad col. AUSTIN 20818, K2628, K4386, 20423 (MANCH), col. WRIGHT D12020, 16515 (G); WRIGHT s/n (NY, F). col. WRIGHT 15-29 (HAC). — JAMAICA: Cinchona plantation 5000 f, col. UNDERWOOD 193 (NY). Cuna-Cuna trail above Mattis river St. Thomas 300–350 m, col. MAXON and KILLIP 161 (F). Green river valley, col. EVANS 212 (HAC). — SANTO DOMINGO: La cumbre, sin colector 1074/18 (ST). — PUERTO RICO: El Yunque, col. BLONQUIST 12696, col. EVANS 127 (NY). col. PAGÁN 845, 854, 871a (NY). — GUADALUPE: Hirandella, col. DUSS 497 (NY). Sin localidad, col. DUMORTIER 16511 (G). sin colector 16529 (G). — DOMINICA: Laudat, col. LLOYD 324/b (NY). — MARTINICA: Mt. Peleé, col. DUSS 665, 672 (NY). Trois Diables 420 m, col. DUSS 33, 497, 498 (NY). Calebase, versant Nord 670 m, col. DUSS 375 (NY). — SAN VICENTE: Sin localidad, sin colector 1074/19 (S). — TRINIDAD: Toco Road Valencia, col. BRITTON, COKER, ROWLAND 757, 1414, 1842, 1838 (NY, FH). Blanchisseuse Road near 102 mile post col. BROADWAY 7876 (NY). Sin localidad, col. DENDLER s/n (NY). — GUATEMALA: Dampine forest near Cobán Dpt Alta Verapaz 1260–1440 m, col. STANDLEY 69372 (F). SE of Tactic Dpt Alta Verapaz 1500 m, col. STANDLEY 10005 (F). — HONDURAS: Lancetilla valley Dpt Atlantida near Tela 200–600 m, col. STANDLEY 54812, 54936, 55590, 56749, 56751, 56752, 56783, 56785, 56802, 56811 (F). Lancetilla col. HERZOG s/n (JE). — COSTA RICA: Santo Domingo Golfo Dulce, col. TONDUZ 15602, 15603, 15572, 15597, 15599 (FI). col. POTTIER 15603 (FI). Talamanca 100 m, col. TONDUZ 15882 (FI). Yerba Buena provincia Heredia, sin colector s/n (JE). Naranjos agrios provincia Guamácaste sin colector s/n (JE). Cobayra, col. FERNÁNDEZ 16502, 16503 (G). Valle Rio Luis Cobayra, col. FERNÁNDEZ 16506 (G). — COLOMBIA: Dpto del Valle, col. CUATRECASAS s/n (F). — VENEZUELA: Estado de Lara cerca de los limites con el Estado Yarucay 1450 m, col. STEYERMARK, SMITH, ESPINOSA s/n (NY). Estado Yarucay, col. STEYERMARK s/n (F), 111734, 119475 (VEN). Estado Bolivar Jaua, col. STEYERMARK 109519, 119474 (VEN). — SURINAME: Sin localidad, sin colector 47445 (L). — BRAZIL: Rio Negro, col. SPRUCE s/n (NY). Santha Catharina, sin colector 366 (FI). Rio de Janeiro, sin colector 422 (FI). Sin localidad, sin colector 165110, 16516 (G), 1047/21 (S). — PERU: Dpto de Loreto, sin colector 16514 (G). — BOLIVIA: Sin localidad, col. HERZOG 16529 (G), 4706, 47444 (L). Sin localidad: 16517 (G) (Isotypus).
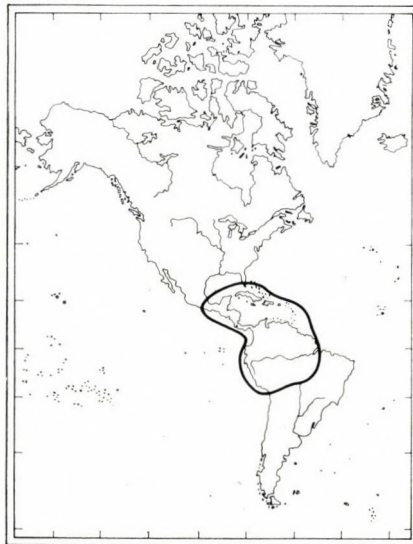
*Fig. 13. Diplasiolejeunea pellucida* (Meissner) Schiffner. Distribución

*Distribución.* — Cuba, Jamaica, Santo Domingo, Puerto Rico, Guadalupe, Dominica, Martinica, San Vicente, Trinidad, México, Guatemala, Honduras, El Salvador, Costa Rica, Colombia, Venezuela, Guyana, Suriname, Brazil, Peru, Bolivia,

## 8. **Diplasiolejeunea pellucida** var. **malleiformis** Evans, Bull. Torrey Bot. 39: 215 (1912)

**Tipo: Puerto Rico, El Yunque, col. EVANS.**

**Las plantas pertenecientes a esta variedad guardan una estrecha relación con la especie *D. pellucida* (Meissner) Schiffner, de la cual nuestra variedad solamente se diferencia en que forman parches totalmente aplanados, sus ramas están adheridas en toda su longitud al sustrato; carecen de ocelo basal en los filidios; el diente apical es siempre maleiforme; el diente posterior es conspícuo, nunca oculto; la papila hialina en posición central; el ápice de los segmentos del anfigastrio está formado por una célula aguda.**

*Material revisado.* — CUBA: Provincia Santiago de Cuba, La Gran Piedra, en frutales viejos Finca Isabelica 1130 m, epífilos, col. PÓCS, REYES, DUANYS 9112/S (HAC, EGR). — PUERTO RICO: El yunque, col. EVANS 10 (NY) (Isolectotype). col. EVANS 120 (NY) (Isosyn-

*Fig. 14. Diplasiolejeunea pellucida* var. *malleiformis* Evans. Distribución

type). — GUADALUPE: Sin localidad, sin colector 16530 (G). — MARTINICA: Mt. Peleé, col. DUSS 665, 672 (NY). — HONDURAS: Valle Lancetilla, epífilos 200–600 m, col. STANDLEY 56783, 56802 (HAC).

*Distribución.* — Cuba, Jamaica, Puerto Rico, Guadalupe, Dominica, Martinica, San Vicente, México, Honduras, El Salvador, Colombia

## 9. **Diplasiolejeunea rudolphiana** Stephani, Hedwigia 35: 79 (1896)

Syn.: *Lejeunea unidentata* sensu Montagne, in Ramón de la Sagra, Hist. Phys. Ile Cuba, Bot., Pl. Cell.: 478 (1842); non (Lehm. et Lindenb.) Mont.

Tipo: Brazil, Petropolis 1890, col. RUDOLPH (G).

Plantas de mediano tamaño con relación a otras especies 9–13 mm de longitud, 2–3 mm de ancho total en la rama principal, Color verde brillante o verde olivo cuando se colectan, pardas cuando secas. Cortícolas o epífilas; cuando cortícolas forman parches compactos comprimidos; cuando epífilas los parches son dispersos no compactos, comprimidos. Ramificaciones irregulares, distantes; las ramas secundarias difieren de la rama principal en su longitud y en el tamaño de los filidios y anfigastios. Rizidios escasos, caedizos, cortos 45–50 μm de longitud, finos 2–5 μm de ancho, transparentes color pardo. Filidios ovados, inserción casi transversal, base de inserción muy corta 62–72 μm; incumbentes, imbricados hacia la cara dorsal; ápice redondeado, margen liso, células del borde 12–15 × 12–17 μm; células centrales 15–22 × 22–25 μm; células basales grandes y alargadas 20–25 × 27–42 μm, con escasos trígonos y espesamientos intermedios. Ocelos no siempre presentes, hasta 8 por filidios, escasos, dispersos, 22–25 × 32–37 μm, sin trigonos ni espesamientos intermedios en la membrana. Lóbulo grande con relación al tamaño del filidio, hinflado, margen libre involuto, quilla arqueada; diente apical agudo, delgado 8–13 células de alto, 2–3 células en la base, oblicuamente esparcido hacia la base del filidio, formado en casi toda su longitud por 1–2 células de ancho, ápice formado por una célula apiculada; diente posterior conspícuo, largo y delgado, a menudo inflexo, 5–8 células de largo, 2 células en la base, raramente inconspícuo formado por una sola célula; Papila hialina alargada, piriforme, situada 2–3 células por debajo de las células de la base del diente apical, posición central. Anfigastrios subimbricados a imbricados, cuando subimbricados dejan ver parte del caulidio; bífidos 1/2 de su longitud total, segmentos cuneiformes, 7–10 células en la base de cada segmento, ápice de los segmentos terminados en una célula cónica; ángulo de abertura de los segmentos ligeramente agudo. Plantas autoicas. Inflorescencie femenina naciendo en una pequeña innovación de la rama principal o una rama secundaria, brácteas aladas a lo largo de la quilla, brácteolas parecidas a filidios y anfigastrios; perianto alargado 2–2.5 mm de alto, 2 mm de ancho, bordes ligeramente crenulados por proyecciones celulares, ápice redondeado, arquegonio pedunculado. Inflorescencia masculina formada por 3–5 pares de brácteas.

*Habitat.* — Esta es la especie que tiene más amplia distribución en el archipiélago cubano, epífilas o cortícolas. Cuando epífilas crecen comúnmente en hojas de cítricos y café, desde la parte central hacia el ápice del limbo de la hoja que le sirve de sustrato; las cortícolas son frecuentes en la corteza de *Pinus* sp. Crecen en diferentes tipos de vegetación a diferentes altitudes, en sabanas arenosas de la Isla de la Juventud, sembrados de frutales, bosques de galería, pluvisilva submontana, en serpentinas de Loma de Galindo; en pluvisilva montana bioclima tipo hipotermexerico de la Sierra del Escambray; en pluvisilva montana del mismo tipo de bioclima en Moa; en bosque siempreverde con bioclima estacional húmedo tropical; en vegetación de bosque nublado con bioclima eumesaxerico de la Sierra Maestra; desconociéndose el tipo de vegetación de colecta de la Península de Guanacahabibes.

*Material revisado.* — CUBA: Isla de la Juventud, La Cunagua orange tree, col. BRITTON 14590 (NY). Hotel Colony, sabana arenosa, col. BISSE et LIPPOLD 12904 (JE). Carretera Cayo Piedras en corteza de *Ateleia* sp., col. DUARTE 531 (HAC, EGR). Provincia Pinar del
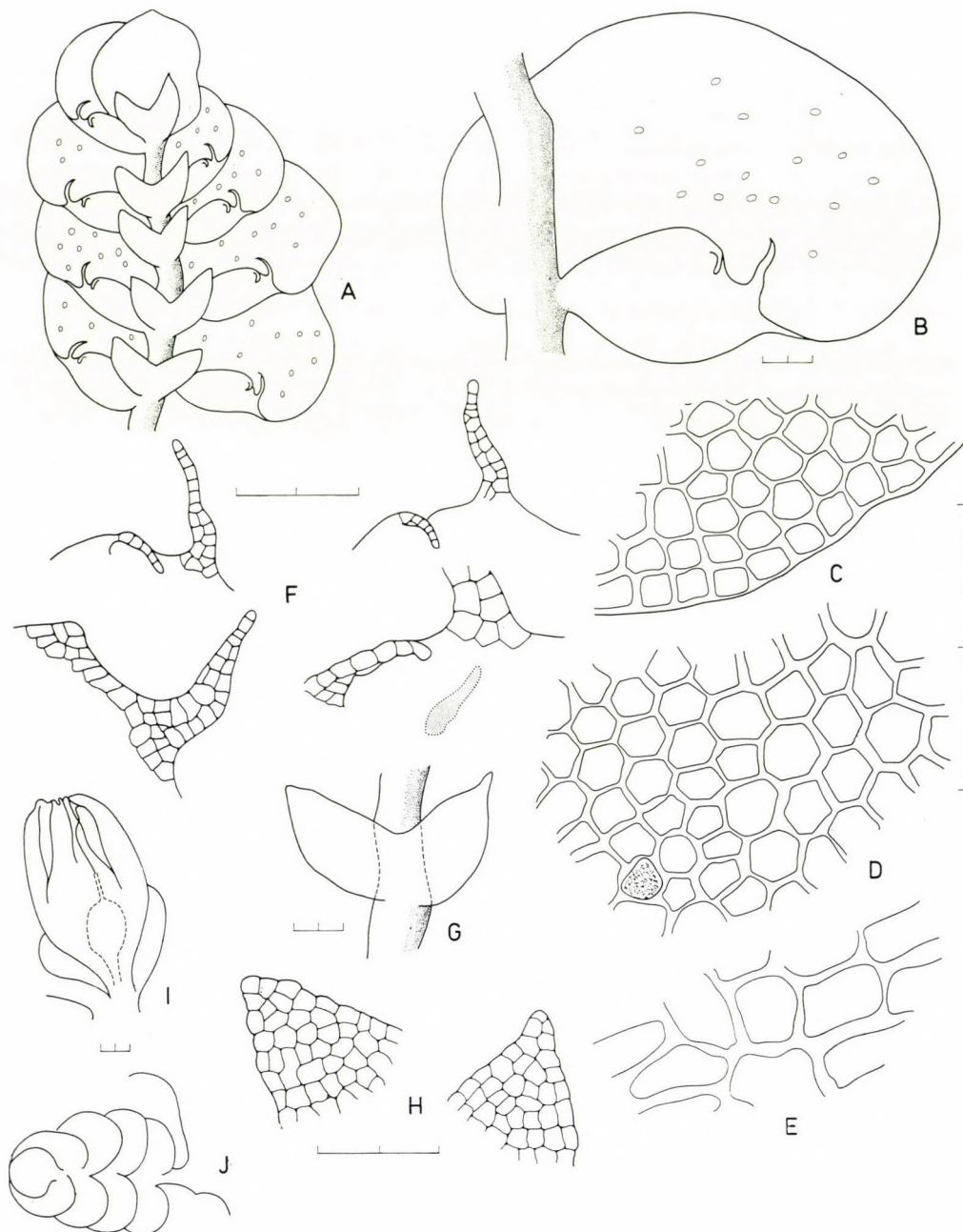
*Fig. 15. Diplasiolejeunea rudolphiana* Stephani — A. Porción de la planta, cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Células de la base del filidio. F. Diente apical, diente posterior, papila hialina. G. Anfigastrio. H. Apice segmento del anfigastrio. I. Inflorescencia femenina. J. Inflorescencia masculina
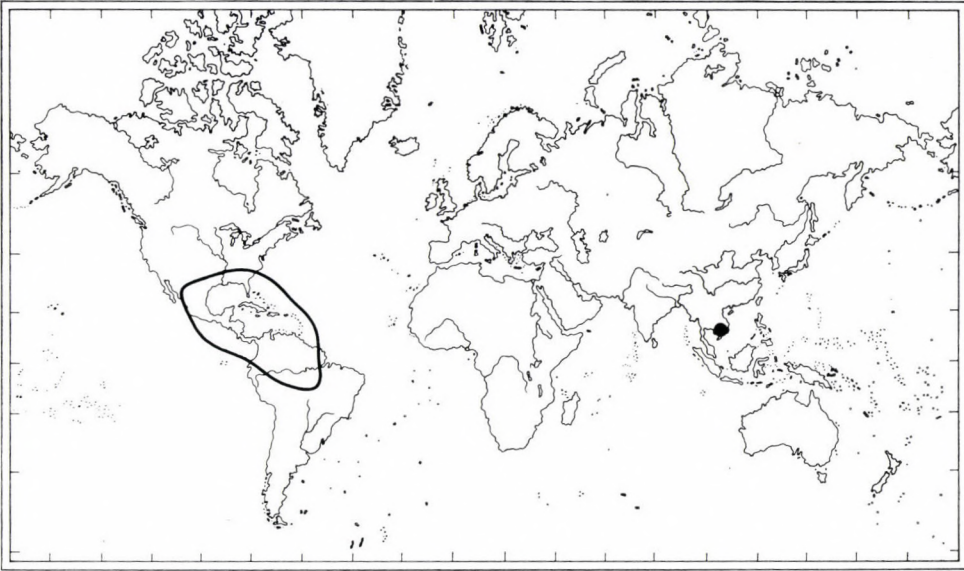
*Fig. 16. Diplasiolejeunea rudolphiana* Stephani. Distribución

Rio, Guanahacabibes La Jaula, Laguna de Lugones, col. SCHUBERT. Alturas de pizarra Guanito, col. SCHUBERT. Sierra del Rosario, epífila, col. SAMEK s/n (JE). 1154/c (H). s/n (PRC) Provincia Matanzas, Canasi Alturas de Galindo 200–300 m, sobre serpentina, col. BISSE et LIPPOLD 10924 (JE). Provincia Sancti Spíritus, Sierra del Caballete Banao, col. LEÓN 24007 (FH). Se Topes de Collantes en cafetales y frutales, al pie N Pico Potrerillo 700–800 m, col. PÓCS et BORHIDI 9007/T (HAC, EGR). Paredón N cima principal Pico Potrerillo en fragmento de pluvisilva montana muy húmeda con muchos epífilos, col. PÓCS et BORHIDI 9012/CD (HAC, EGR). Provincia Santiago de Cuba, Pico Suecia, Sierra Maestra 1700–1750 m, ramícolas, col. BORHIDI, MUÑÍZ y VÁZQUEZ 5841 (JE, HAC, EGR). Cobre, col. WRIGHT s/n (FH). La Gran Piedra Finca Isabelica, monte nublado 1130 m, epífilos, col. PÓCS, REYES y DUANYS 9112/BP (HAC, EGR). Provincia Holguín, Cuchillas de Moa, Punta Gorda E de Moa Pinares sobre rocas serpentinas Rio Yagrumaje 200 m, cortícolas, col. PÓCS y REYES 9166/A (HAC, EGR). Moa hacia la Melba km 18, col. LIPPOLD 12198, 12212b, 12213a (JE). Provincia Guantánamo, Sierra del Purial 6 km al N Puriales de Caujerí, cimas sobre Rio Toa 600–650 m, bosque siempre verde, epífilos, col. PÓCS, REYES, CALUFF 9185/BO. Yateras cerca La Clarita Monte Verde, bosque siempreverde, epífilos col. PÓCS, CALUFF 9181/AD (HAC, EGR). Monte Cristo, col. BISSE et LIPPOLD 10129 (JE). col. SAMEK s/n (JE). col. SAMEK 1156 (PRC). Cupeyal 5 km E, col. SCHUBERT s/n (PRC). Monte Verde, col. WRIGHT s/n (FH). Sin localidad, col. AUSTIN 20817 (MANCH). col. WRIGHT k2600 (MANCH). Hepaticae cubenses wrightianae s/n (FH). sin colector 16539 (G). 1074/28 (S). — BAHAMAS: Lake Cunningham, col. BRITTON 645a (NY). Coppice soldiers Road, col. BRITTON 820 (NY). Rifle Range Coppice, col. BRITTON 561a (NY). Coppice near Clifton, col. BRITTON 6633 (NY). — JAMAICA: Sin localidad, col. UNDERWOOD 30 (NY). — HAITI: Bayeux, col. NASH 165 (NY). — PUERTO RICO: Cayey, cortícola, col. EVANS 102 (NY, FI). s/n (HAC, EGR). — DOMINICA: Hepaticae dominicenses Elliottionae 19383 (G). — TRINIDAD: Sin localidad, sin colector 16538 (G). — FLORIDA: Tenthousand Islands, col. SWALL 7553 (NY). Everglade Miami, col. SWALL 5267 (NY). Hillsboro, col. KEATING 29 (NY). col. JOHNSON 27 (NY). Highlands, col. JOHNSON 17 (NY). Sanford col. RAPP 682 (NY). — MÉXICO: Motzorongo, col. SMITH 8 (NY). Oaxaca, col. MICKEL s/n: (FH). col. UNDERWOOD 16544 (G). Sin localidad, sin colector 16537 (G). — HONDURAS Lancetilla, col. STANDLEY 5536/a, 55354 (F). col. HERZOG s/n (JE). Departamento de Cortés Rio Lindo, col. MORTON 7879 (F). — PANAMA: Sin localidad, sin colector 19385 (G). — COLOMBIA: Potumayo, col. GUEVARA C1074 (F). — VENEZUELA: Meseta de Jaua, col.

Steyermark 98094, 11947 (G). 119477, 119478 (VEN). — SURINAME: Sin localidad, sin colector 4744/6, 7, 8 (L). — BRAZIL: Sao Paolo, sin colector 1074/27 (S).

*Distribución.* — Cuba, Bahamas, Jamaica, Haití, Puerto Rico, Guadalupe, Dominica, Trinidad, Florida, México, Honduras, Panama, Colombia, Venezuela, Suriname, Guyana, Brazil

## 10. **Diplasiolejeunea unidentata** (Lehmann et Lindenberg) Schiffner, Bot. Jahrb. Syst. 23: 583 (1897)

Syn.: *Jungermannia unidentata* Lehmann et Lindenberg, in Lehmann, Nov. Min. Cogn. Stirp. Pugillus b: 48 (1834)

*Lejeunea unidentata* (Lehmann et Lindenberg) Montagne in Ramón de la Sagra, Hist. Phys. Ile Cuba, Bot., Pl. Cell.: 478 (1842), Spruce, Trans. Proc. Bot. Soc. Edinburgh 15: 302 (1884)

Tipo: St. Vincent.

Plantas de mediano tamaño con relación a otras especies 9–13 mm de longitud, 2 mm de ancho total el la rama principal. Color verde brillante o verde olivo cuando se colectan, blanquecinas a pardas cuando secas. Epífilas o cortícolas. Forman parches dispersos no compactos cuando epífilos, y parches compactos y densos cuando cortícolas. Rizidios largos 75–100 μm de longitud, 10–20 μm de ancho, muy numerosos, persistentes, transparentes, incoloros o ligeramente pardos; a diferencia de los rizidios en *D. unidentata*, en esta especie los rizidios a las 3/4 partes de su longitud total se ramifican, siendo más cortos, numerosos y gruesos que los de *D. rudolphiana*. Crecen en tupido fascículo sobre paranfigastrio. Caulidio robusto y sinuoso, según Bischler (1961), en la anatomia interna está formado por 7 células corticales grandes y alargadas 7–24 × 19 μm, y 3 células medulares pequeñas y cortas 3–18 × 16 μm, con espesamientos en las membranas. Filidios ovados a suborbiculares, inserción longitudinal a casi transversal, base de inserción corta 75–87 μm; incumbentes, imbricadas hacia la cara dorsal, a veces, se forma un ligero doblez en el margen superior del filidio, células del borde 12–15 × 10–15 μm con trígonos y espesamientos intermedios escasos, células centrales 20–25 × 17–20 μm con escasos trígonos y espesamientos intermedios, células basales 37–40 × 17–25 μm con trígonos y espesamientos intermedios abundantes a diferencia de la *D. rudolphiana*, donde son más escasos. Ocelos bastante constantes en el número, 10–12 por filidio, no siempre presentes, dispersos, 20–22 × 25–30 μm, sin trígonos ni espesamientos intermedios. Lóbulo grande con relación al tamaño del filidio, hinflado, con margen libre involuto en parte, la parte libre del margen adherida al filidio, por lo que se forma un pliegue; quilla arqueada; diente apical agudo, 6–8 células de largo, 2–3 células en la base, cuneiforme, y extendido; diente posterior indistintamente conspícuo o inconspícuo, o simplemente una crenulación celular, a menudo oculto por el margen libre; papila hialina más pequeña que en *D. rudolphiana* y más próxima a la base que en esa especie; posición central con relación a la base del diente apical. Anfigastrios subimbricados a distantes, bífidos 1/2 de su longitud total, segmentos cuneiformes, 10–12 células en la base de cada segmento, ápice de los segmentos redondeados, a diferencia de *D. rudolphiana* donde terminan en una célula cónica. Plantas autoicas. Inflorescencia femenina creciendo en una pequeña innovación en una rama secundaria, o en la rama principal, brácteas con un ala estrecha a lo largo de la quilla, bordes lisos; arquegonio pedúnculado. Inflorescencia masculina en una pequeña innovación ocupando, generalmente, la misma rama de la inflorescencia femenina; formada por 3–6 brácteas, anteridios pedúnculados. Esporofito típico de las Lejeuneaceas, formado por pedúnculo articulado 2 mm de longitud, coronado por esporangio que se abre en 4 val vas iguales, color pardo. Elaterios en forma de huso alargados 216 μm, aguzados en un extremo, ensanchado hacia la otra extremidad, rematado por un engrosamiento de donde parten dos bandas o espirales dobles.

*Habitat.* — Epífilas, ramícolas o cortícolas. Cuando son epífilas crecen formando parches no compactos, sencillos en toda la superficie del limbo de las hojas; cuando son ramícolas o
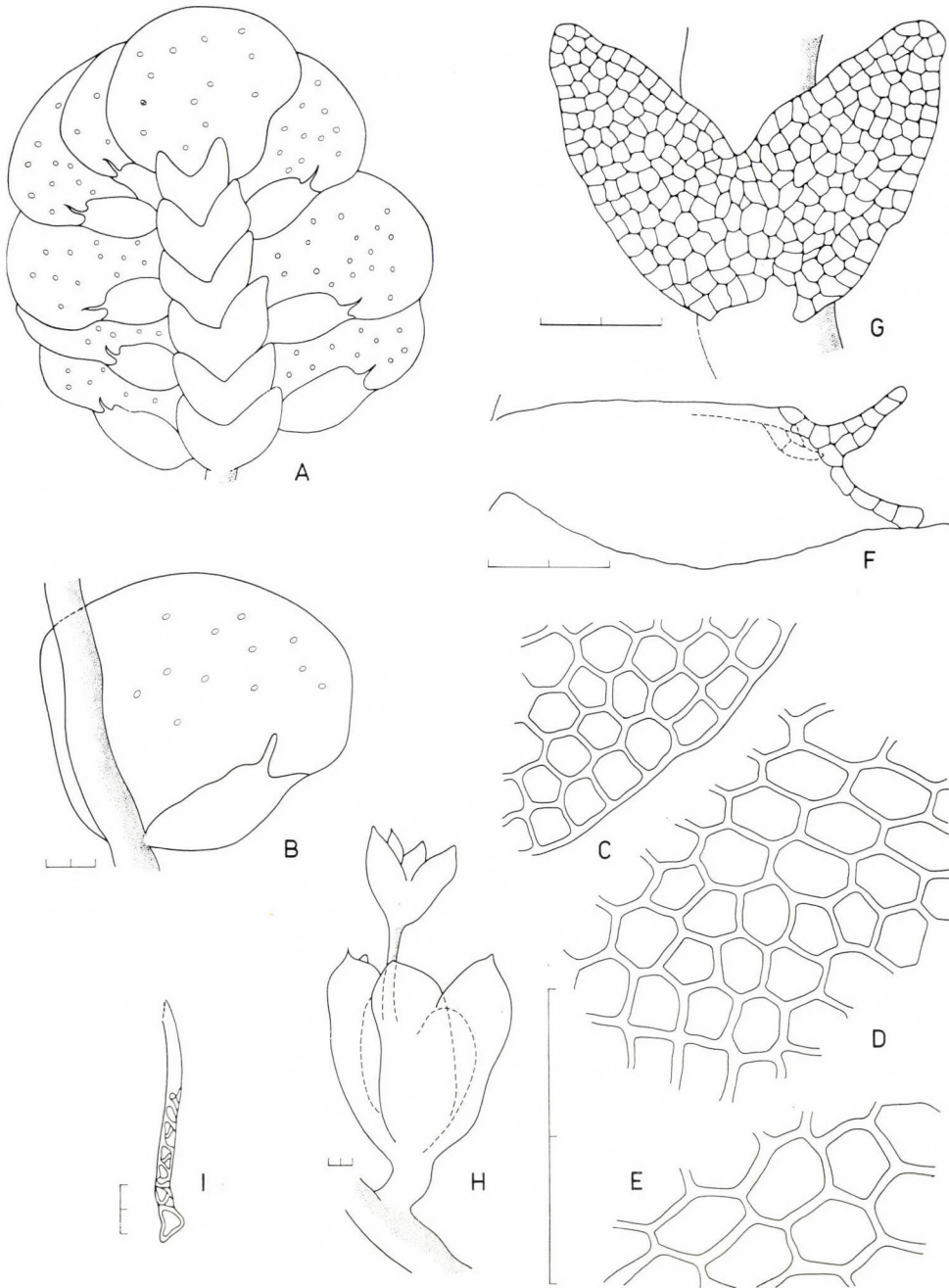
*Fig. 17. Diplasiolejeunea unidentata* (Lehman et Lindenberg) Schiffner — A. Porción de la planta, cara ventral. B. Filidio. C. Células del borde del filidio. D. Células del centro del filidio. E. Células de la base del filidio. F. Lóbulo. G. Anfigastrio. H. Esporofito. I. Elaterio

cortícolas los parches son más compactos y densos, con especial preferencia por la corteza de *Pinus* sp. crecen tipo de vegetación de bosque siempreverde en tipo de bioclima húmedo, tropical en pluvisilvas montanas también en tipo de bioclima húmedo tropical, y en bosque nublado tipo de bioclima eumesaxerico.

*Material revisado.* — CUBA: Provincia Sancti Spíritus, Sierra del Caballete, col. León et Clemente 6578 (NY). SE Topes de Collantes 700 m, epífilos, col. Pócs et Borhidi 9007/R (HAC, EGR). Provincia Granma, Cresta E Pico Palma Mocha, epífilas, col. Pócs y Duanys 9081/AG, AF (HAC, EGR). Provincia Santiago de Cuba, Pico Real del Turquino Sierra Maestra sobre *Scolosanthus maestrensis* Alain, col. Borhidi, Muñíz et Vázquez 584 (HAC, EGR). col. Acuña 22126 (HAC). Pico Suecia, Sierra Maestra 1700–1750, epífilos, col. Borhidi, Muñíz y Vázquez 5858 (HAC, EGR). El Cobre, col. Wright s/n (F). Gran Piedra 1100 m, epífila, col. Reyes 2713 (HAC). col. Pócs y Reyes 9012/CA (HAC, EGR). Provincia Holguín, Cuchillas de Moa 2 km al N La Melba cerca Cascada Dos Comadres, bosque siempreverde sobre rocas de serpentina 400 m, epífilos, col. Pócs y Reyes 9170/CK (HAC, EGR). Provincia Guantánamo, Sierra del Purial, 6 km al N Puriales de Caujerí, detrás de Bejuquera, cimas Río Toa 600–650 m, bosque siempreverde, epífilos col. Pócs, Reyes, Caluff 9185/BO (HAC,
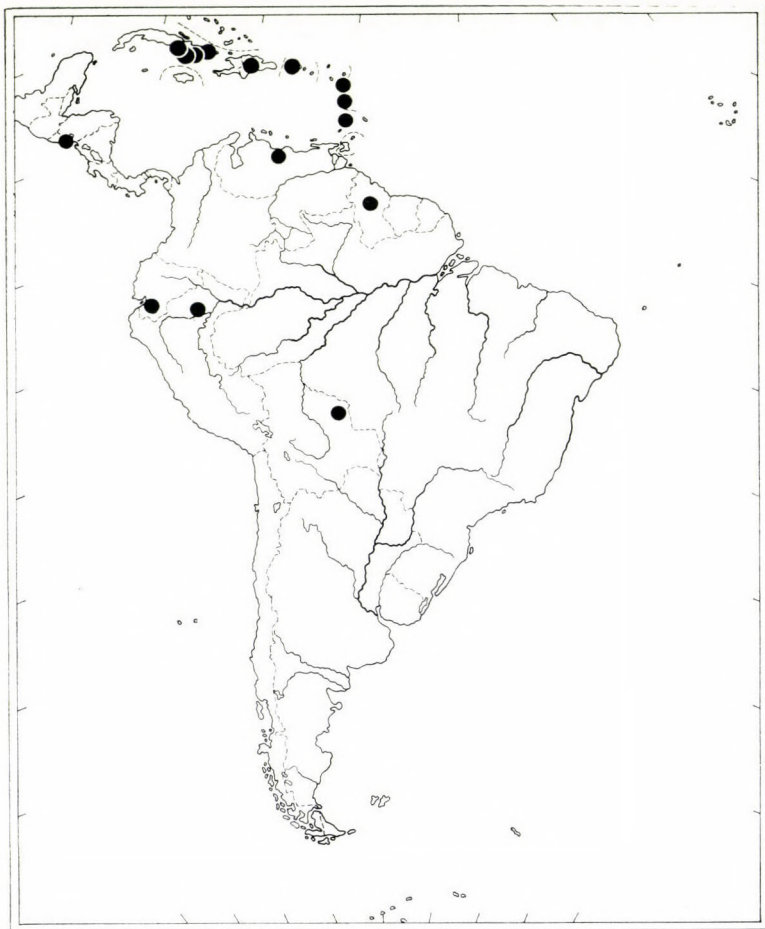
*Fig. 18. Diplasiolejeunea unidentata* (Lehman et Lindenberg) Schiffner. Distribución (localidad en Mexico no marcado)

EGR). Escarpa E y cima del Yunque de Baracoa 450–540 m, col. Pócs y Reyes 9064/AG (HAC, EGR). — PUERTO RICO: Luquillo Mts, El Yunque, col. Evans 2, 120, 127, 154 (NY). col. Pagán 2238 (NY). — GUADALUPE: Sin localidad, col. Duss 566, 16540 (G). sin colector 6535 (G). — DOMINICA: Hepaticae dominicenses Elliottinae 16549 (G). — MARTINICA: Deux-Choux, col. Duss 663 (NY). Sin localidad, 440 m, col. Duss 663 (NY). col. Dumortier 16507, 16543 (G). Sin localidad, sin colector 16532 (G). — SAN VICENTE: Sin localidad, sin colector 1074/29 (S). — VENEZUELA: Caracas, sin colector 19386 (G). sin localidad, col. Müller 16546 (G). — ECUADOR: Pichincha, epífila, col. Crosby s/n (HAC, EGR). — PERU: Amazonas, Chachopoyas, epífila, col. Wurdack s/n (HAC). Sin localidad, col. Müller 16536 (G). — BOLIVIA: Coroico, epífila, col. Mahunka 79/a (BP, HAC).

*Distribución.* — Cuba, Jamaica, Puerto Rico, Guadalupe, Dominica, Martinica, San Vicente, México, El Salvador, Venezuela, Guyana, Ecuador, Peru, Bolivia

## 11. **Diplasiolejeunea pocsii** Reyes spec. nova

Plantae epiphyllae, ad substratum valde adhaerentes; Rizidia parca, simplicia, hyalina, decidua; caulidia robusta. Phyllidia ovata, margine hyalina, e stratis cellularibus 1–9 formata. Cellulae centrales limbi foliaris 7–12 × 10–15 μm, cellulae basales 10–15 × 17–18 μm, parietibus in angulis trigonaliter incrassatis et cum incrassamentis intermediariis suffulta. Ocelli 18–22 per phyllidia. Ocelli basales 1–2 per phyllidia, constantes. Lobulus magnus, inflatus, margine libero partialiter involuto. Dens apicalis plerumque malleiformis, 2–3 cellulae alta, apex e cellulis hyalinis 2–4 formatus, medio dentis cum una sola cellula magna et lata praedita. Dens media conspicua, versus dentem apicalem curvata sinum rotundatum formans; apex dentis semper ex una cellula apiculata hyalinaque formatus. Amphigastria parva, distantia, inter illa caulo conspicuo, bifida usque ad 3/4 longitudine, apice segmentorum in unam cellulam hyalinam terminanti.

*Holotypus:* Pócs et Reyes 9170/CM (HAC). Cuba, Prov. Holguin; Cuchillas de Moa, Cascata Dos Comadres supra pag. La Melba, 400 m.s.m. Isotypus: EGR.

Plantas de medianas a grandes 13–18 mm de longitud, 1.5–2.5 mm de ancho total en la rama principal. Color verde brillante cuando se colectan, blanquecinas cuando secas. Epífilas formando parches pequeños, no compactos, comprimidos, fuertemente adheridos al sustrato, se diferencia de la *D. pellucida* por estas características diferenciales. Ramificación regular, distante; ramas secundarias idénticas a la rama principal. Rizidios poco numerosos, caedizos, incoloros, transparentes, largos 50–55 μm de longitud, en la *D. pellucida* son numerosos, persistentes, más largos, más finos, coincidiendo en su color; ambos forman fascículos en el paranfigastrio. Caulidio robusto 75–82 μm de ancho, sinuoso, con anatomía interna idéntica a la de *D. pellucida.* Filidios ovados, inserción en el caulidio transversa, base de inserción muy corta 30–40 μm, mucho más corta que en *D. pellucida*; margen hialino bordeando el margen del filidio desde 3/4 partes de longitud del margen superior donde presenta 1–3 estratos celulares, igual en el margen inferior; esta banda hialina se hace más ancha en la medida que se acerca al ápice donde llega a tener 6–9 estratos celulares; células por debajo del margen hialino casi cuadradas 10–15 × 7–12 μm; celulas del centro del filidio 12–17 × 7–12 μm; células del centro de la base del filidio 15–17 × 10–15 μm con trígonos y espesamientos intermedios. Ocelos más o menos numerosos 18–22 por filidio, dispersos, a veces agrupados, 15–17 × 20–25 μm; los ocelos son más grandes y numerosos que en *D. pellucida*; los ocelos
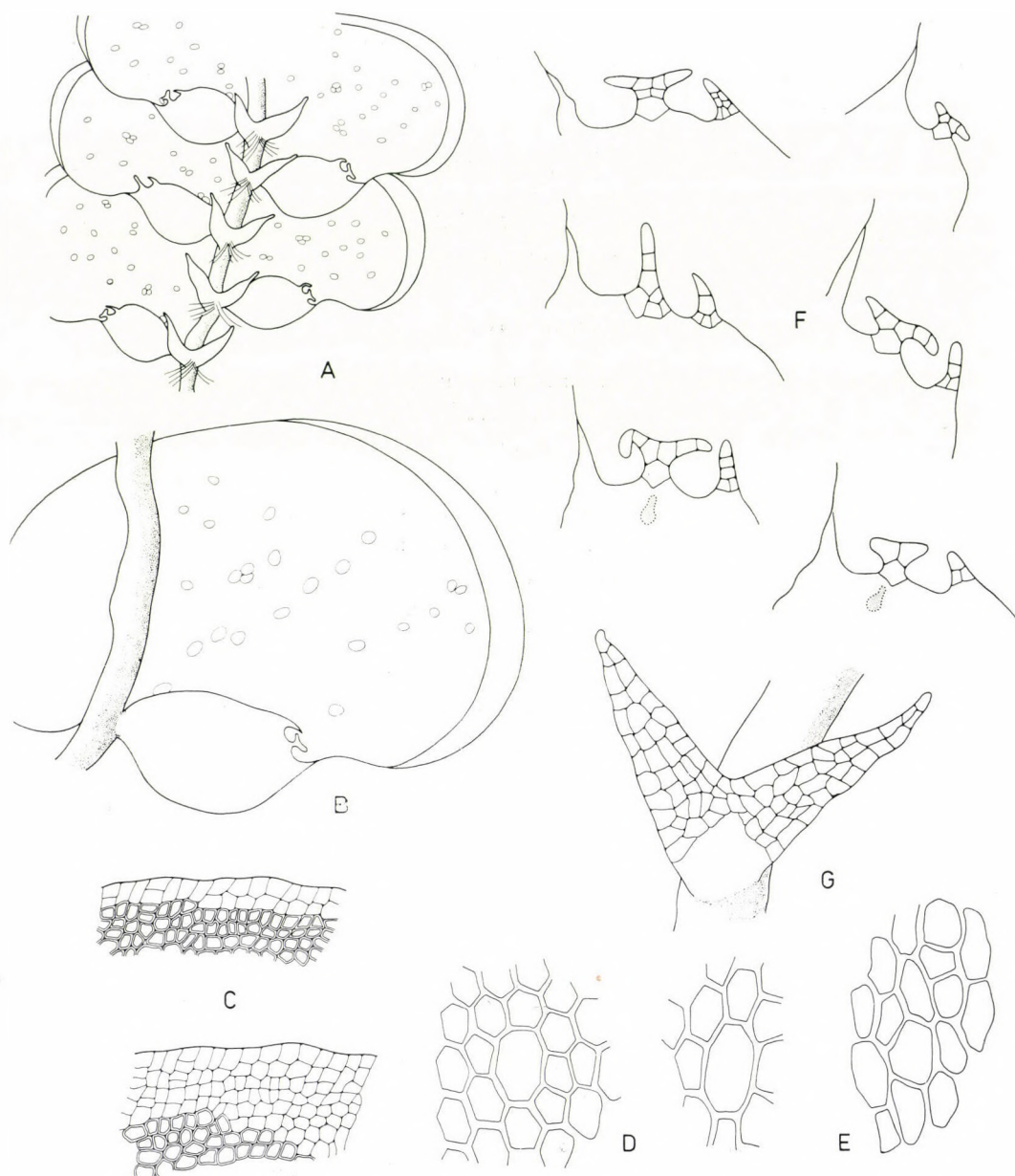
*Fig. 19. Diplasiolejeunea pocsii* Reyes spec. nova — A. Porción de la planta, cara ventral. B. Filidio. C. Margen hialino. D. Células centrales del filidio. E. Células basales del filidio. F. Diente apical, diente posterior, papila hialina. G. Anfigastrio

carecen de trígonos y espesamientos intermedios. Hacia la base del filidio en el margen superior del lóbulo aparecen 1–2 ocelos basales grandes 22–25×35–37 μm, constantes. Lóbulo grande con relación al tamaño del filidio, hinflado, margen libre involuto en parte, borde inferior del lóbulo crenulado quilla arqueada formando linea continua con el margen inferior del filidio, Diente apical generalmente maleiforme, formado de 2–3 células de alto, el ápice coronado por 2–4 células, las de los extremos siempre hialinas apiculadas las células del centro del diente cortas y anchas, la base del diente apical formada por una sola célula muy grande y ancha; diente posterior agudo, conspicuo, curvado hacia el diente apical con el cual forma un ángulo abierto y redondeado semejante al que se forma en D. cavifolia; el diente posterior 2–4 células de alto, con el ápice siempre formado por una célula hialina apiculada; Papila hialina central. Anfigastrios pequeños en relación con el tamaño de los filidios, distantes, dejando ver parte del caulidio, bífidos 3/4 partes de su longitud total, 5–6 células en la base de cada segmento, ángulo de abertura de los segmentos muy abierto redondeado, bordes lisos, ápices de los segmentos agudos terminados en 1–2 células hialinas apiculadas. Planta estudiada estéril.

*Habitat.* — Epífilas, formando parches no compactos, dispersos y muy aplanados, crecen preferentemente hacia la parte apical del limbo de las hojas que les sirven de sustrato, crecen en bosque siempreverde sobre rocas de serpentina.

## 2. **Diplasiolejeunea grolleana** Reyes spec. nova

Plantae epiphyllae ad substratum non adhaerentes. Rhizidia ramificata, rariter simplicia, persistentia, numerosa. Phyllidia ovata, margine limbi inferne rariter revoluto; cellulae centrales 22–25×20–22 μm parietibus in angulis trigonaliter et medio globose incrassatis; cellulae basales 22–25×27–35 μm, cum parietibus incrassamentis trigonalibus atque intermedialibus abundante dispositis. Lobulus magnus, inflatus, dens apicalis malleiformis, rariter simplex, 3–5 cellulae alta et 1–2 cellulae lata, 1–4 cellulis plerumque hyalinis coronata, frequenter cum cellulis hyalinis apicalibus superpositis. Dens media conspicua, 2–4 cellulae alta, cum dente apicali sinum rotundatum formans. Amphigastria continua, bifida ad 1/3 longitudinis, apices segmentorum rotundati. Plantae dioicae ( ?); racemi masculini bracteati, bracteae 8–12 pares, adpresse imbricatae.

*Holotypus:* Pócs et Reyes 9057/GA (HAC). Prov. Santiago de Cuba, Gran Piedra, in silvis nebulosis vertice cimae septentrionali in alt. 1050 m.s.m., prope Cafeteriam. Isotypus: EGR.

*Specimina examinata:* Pócs et Reyes 9057/GC, ibidem.

Plantas grandes con relación al tamaño de otras especies dentro del género 14–17 mm de longitud, 2–2.5 mm de ancho total en su rama principal. Color verde olivo cuando se colectan, blanquecinas o pardas cuando secas. Epífilas, forman parches no compactos, dispersos. Ramificaciones irregulares, distantes; ramas secundarias de longitud menor y filidios y anfigastrios más pequeños que la rama principal. Rizidios 100–112 μm de longitud, 12–15 μm de ancho, ramificados 3/4 parte de su longitud total, raras veces no ramificados, incoloros transparentes, numerosos, persistentes, crecen en fascículo sobre paranfigastrio. Caulidio robusto 100–125 μm de ancho, en un corte transversal formado pro 7 células corticales y 3 células medulares, con espesamientos en la membrana. Filidios ovados, ápice redondeado,
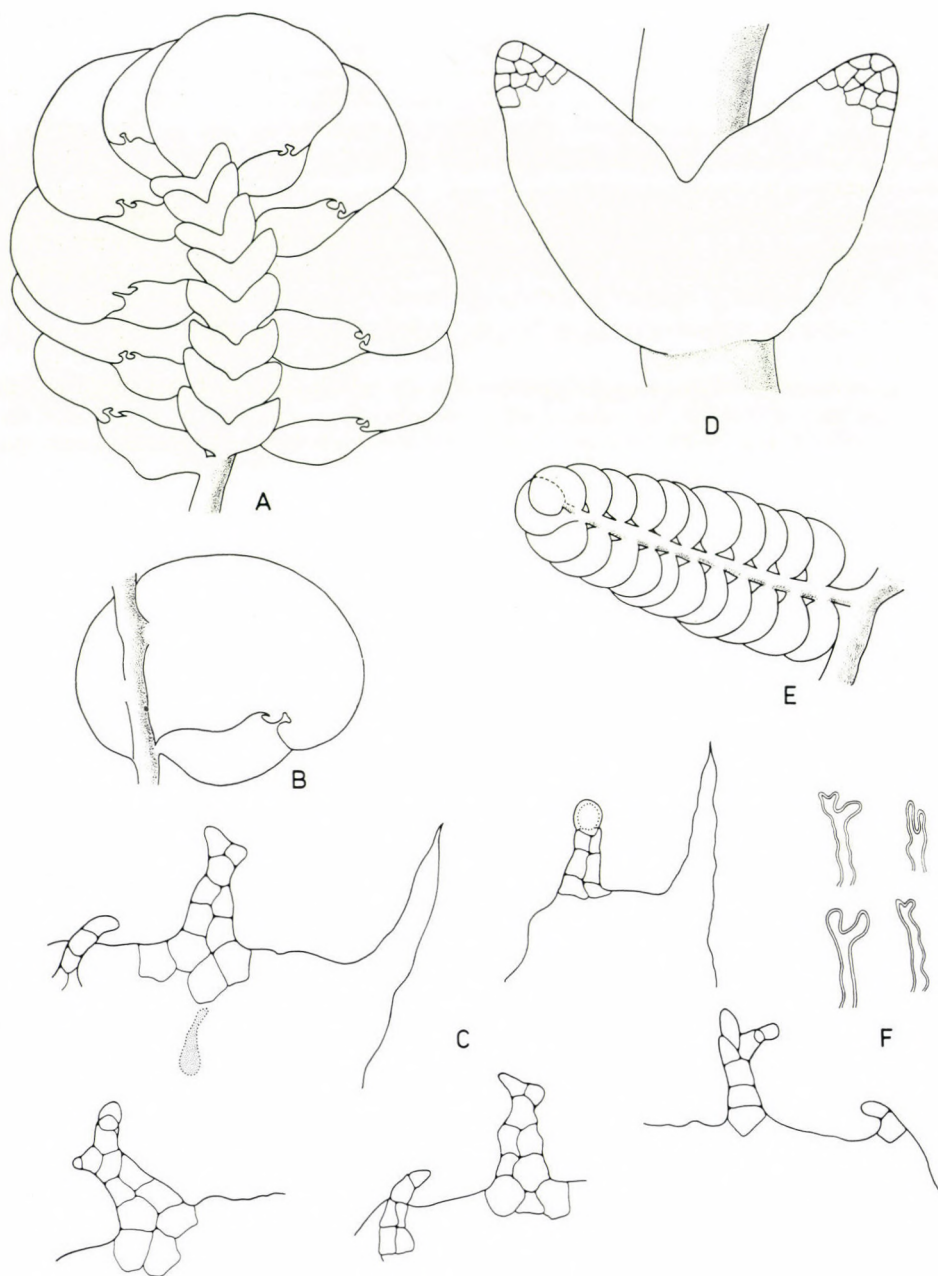
*Fig. 20. Diplasiolejeunea grolleana* Reyes spec. nova — A. Porción de la planta, cara ventral. B. Filidio. C. Diente apical, diente posterior, papila hialina. D. Anfigastrio. E. Inflorescencia masculina. F. Rizidios

margen inferior a veces revoluto; inserción transversal, base de inserción muy breve 20–25 mm, imbricados hacia la cara dorsal; células del borde 12–17×17–20 μm con trígonos y espesamientos intermedios; células del centro 20–22×22–25 μm con espesamientos intermedios y trígonos; células de la base 22–25×27–35 μm con numerosos trígonos y espesamientos intermedios. Ocelos no presentes. Lóbulo grande con relación al tamaño del filidio, células del lóbulo con trígonos y espesamientos en las membranas, margen libre involuto en parte; quilla arqueada formando una línea contínua con el margen inferior del filidio; diente apical generalmente maleiforme, raras veces agudo; cuando el diente apical es maleiforme presenta 3–5 células de alto, 2–3 células de ancho 2–3 células grandes en la base, coronado por 2–4 células casi cuadradas, cuando el diente apical es agudo el ápice está formado por 1 célula cuadrada o cónica; diente posterior conspícuo, formando un ángulo redondo con el diente apical, a menudo curvado hacia el diente apical; papila hialina piriforme 40–50 μm de longitud, 15 μm de ancho en la parte más ancha, situada en el centro de la base del diente apical. Anfigastrios pequeños con relación al tamaño de los filidios, contiguos, dejando ver parte del caulidio, bífidos 1/2 de su longitud total ángulo de abertura de los segmentos abierto agudo, ápice de los segmentos redondeado, 7–9 células en la base de cada segmento, base de inserción redondeada. Plantas dioicas? Inflorescencia masculina creciendo en pequeña innovación de ramas secundarias, formada por 8–12 pares de brácteas; brácteas y brácteolas más pequeñas que filidios y anfigastrios, brácteas apretadamente imbricadas.

*Habitat.* — Epífilas, formando parches no compactos, dispersos por toda la superficie del limbo de las hojas que les sirven de sustrato, crecen en vegetación de bosque nublado a 1050 m en bioclima tipo estacional húmedo de la Gran Piedra.

*Distribución.* — Cuba

## 13. **Diplasiolejeunea borhidiana** Reyes spec. nov.

Plantae epiphyllae, ad substratum adhaerentes. Rhizidia simplicia, numerosa, persistentes. Phyllidia ovata subimbricata, margine limbi superiore late rotundato, inferiore paullo arcuato carenam versus. Cellulae marginale 11–14×11–14 μm parietibus intermedialiter incrassatis; cellulae centrales 11–15×12–15 μm cum incrassamentis trigonalisus intermedialibusque; cellulae basales 17–19×20–22 μm cum incrassamentis trigonalibus et intermedialibus abundante dispositis. Lobulus magnus, inflatus, dens apicalis malleiformis, 4–6 cellulae alta et 3–4 cellulae lata, cellulis 3–5 quasi quadratis coronatus; dens media ab margine libero involuto occulta. Amphigastria parva, distancia, bifida usque ad 3/4 longitudinis; apices segmentorum acuti. Planta examinata sterilis.

*Holotypus:* Cuba; Hepaticae Cubenses Wrightianae s.n. (FH).

Plantas grandes con relación al tamaño de otras especies del género, 15–20 mm de longitud, 2 mm de ancho total de la rama principal. Blanquecinas cuando secas. Epífilas, formando parches aplanados, no compactos, dispersos. Caulidio robusto 25–37 μm de ancho, sinuoso de ramificación irregular y distantemente esparcidas. Rizidios numerosos, alargados, simples, persistentes, incoloros, transparentes, formando fascículo sobre paranfigastrio. Filidios de inserción transversal, base de inserción muy corta, incumbentes, subimbricados hacia la cara dorsal, de forma ovados, margen superior ampliamente redondeado, el margen inferior ligeramente arqueado hacia la quilla, células del borde pequeñas 11–14×11–14 μm con espesa-
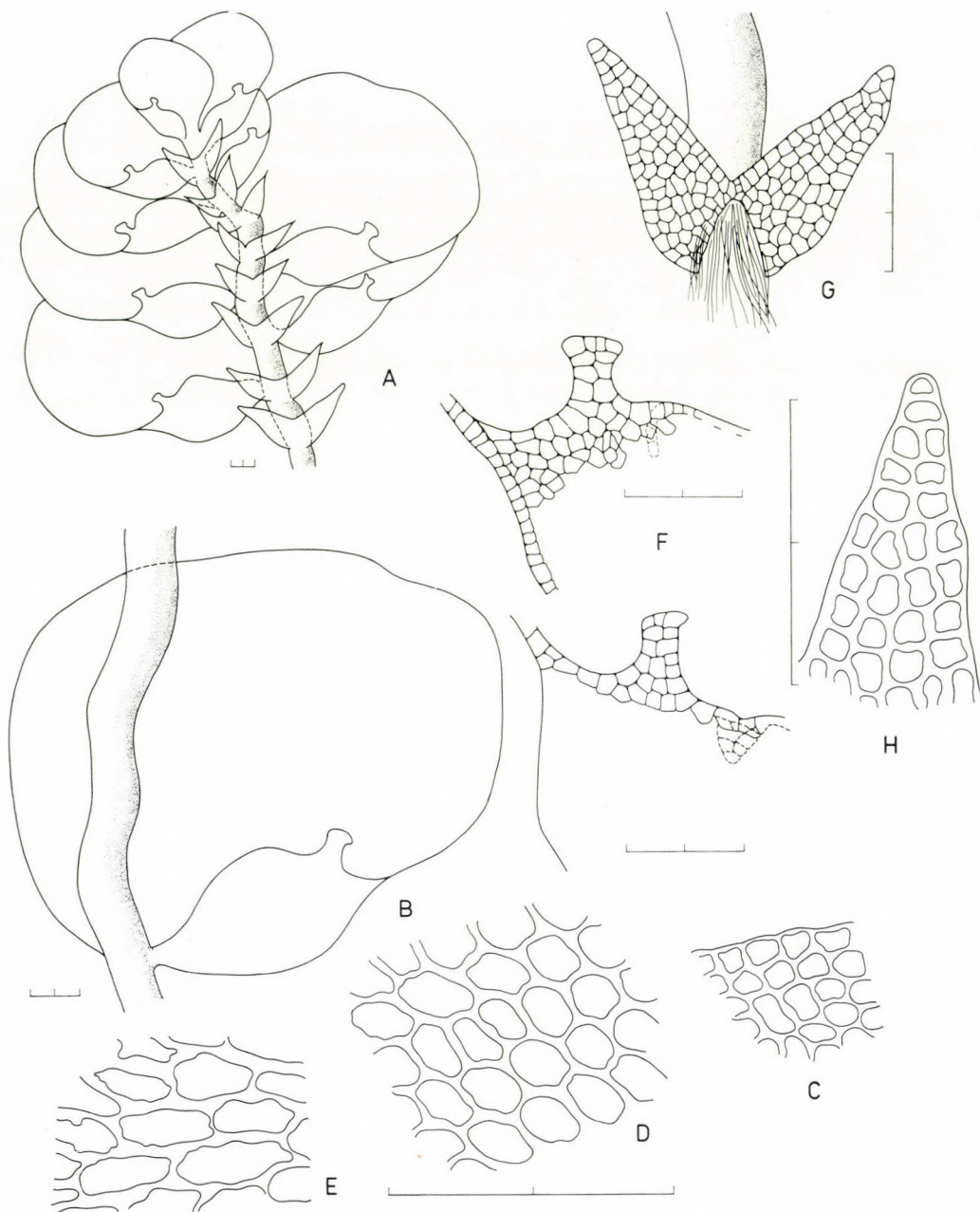
*Fig. 21. Diplasiolejeunea borhidiana* Reyes spec. nova — A. Porción de la planta, cara ventral. B. Filidio. C. Células del borde de los filidios. D. Células del centro del filidio. E. Células de la base del filidio. F. Diente apical, diente posterior, papila hialina. G. H. Anfigastrio

mientos intermedios en las membranas, células centrales 12–15 × 11–15 $\mu$m con trigonos y espesamientos intermedios, células de la base 17–19 × 20–22 $\mu$m con trígonos y espesamientos intermedios. Ocelos no presentes. Filidios no adheridos al sustrato. Lóbulo de mediano tamaño con relación al tamaño del filidio, aplanado, margen libre involuto en parte; diente apical maleiforme con 4–6 células de alto, 3–4 células de ancho, coronado por 3–5 células casi cuadradas no hialinas; diente posterior conspicuo, oculto por involución del margen libre, 2–3 células de alto.

Papila hialina central con relación a la base del diente apical. Anfigastrios pequeños con relación al tamaño de los filidios, distantes, dejando ver parte del caulidio, bífidos 3/4 de su longitud total, ápice de los segmentos agudo terminados en una célula aguda, ángulo de abertura de los segmentos abierto y agudo, base de inserción redondeada. Planta observada estéril.

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# EXAMINATION OF THE PHOTOSYNTHETIC FIXATION $^{14}CO_2$ ON BRYOPHYTE AND LICHEN SPECIES

J. Suba, A. Kiszely-Vámosi, Gy. Légrády, and S. Orbán

BOTANICAL DEPARTMENT OF THE HO-SI-MINH TEACHERS' TRAINING COLLEGE, EGER, HUNGARY

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Photosynthetic productivity of bryophyte and lichen species living in beechwood and rock-sward communities were studied. The intake of $CO_2$ was established from the photosynthetic fixation of $^{14}CO_2$. The $CO_2$ intake of bryophytes is similar to that of the flowering plants, while that of the lichens is 5–6 times less. Productivity of *Rhodobryum spathulatum* is prominent: 11.69 mg $g^{-1}h^{-1}$. Hygro- and mesophyte mosses showed higher photosynthetic intensity than xerophytes. Bryophytes of the beechwood community bind more $CO_2$ on the average then rock-inhabiting mosses. In lichens, *Peltigera* and *Collemma* species were characterized by higher values. Photosynthetic productivity of lichens having a looser cortex and more cavernous structure is generally higher.

## Introduction

Several publications have dealt with the photosynthesis of bryophytes and lichens. In these publications however mainly the influence of environmental factors — light, $CO_2$, heat, water — was studied. Our objective was to establish the photosynthetic activity of bryophyte and lichen species, characteristic of a typical plant community under identical experimental conditions. Summarizing of the values of greater number of species drawn into the examination affords an opportunity also to compare the productivity of the individual bryophytes and lichens. We searched for a connexion between the photosynthetic intensity and ecological, structural features of the species as well as their place in the systematics. Sampling areas were delined in the Bükk mountains, and 19 bryophyte and 24 lichen species from the beechwood community of the "Primeval forest", and 17 bryophyte species from the diabase rocks of Szarvaskő were tested.

The photosynthetic intensity of the species was established on the basis of $^{14}CO_2$ fixation. The initial results of our examinations are presented in the study.

## Material and method

The following bryophyte species (19) were collected from *Aconito-Fagetum* community of the "Primeval forest" in the Bükk mountains (abbreviation of their names and also their numbering are indicated).

1. *A. s.* *Amblystegium serpens*
2. *A. v.* *Anomodon viticulosus*
3. *B. r.* *Brachythecium rutabulum*
4. *B. r.* *Brachythecium rutabulum* (from an other population)
5. *B. r.* *Brachythecium rutabulum* (from an other population)

6. *B. f.* *Bryum flaccidum*
7. *C. t.* *Cirriphyllum teniunerve*
8. *D. u.* *Drepanocladus uncinatus*
9. *H. ph.* *Homalothecium philippeanum*
10. *H. c.* *Hypnum cupressiforme*
11. *L. p.* *Leskea polycarpa*
12. *L. n.* *Leskeella nervosa*
13. *L. n.* *Leskeella nervosa* (from an other population)
14. *L. h.* *Lophocolea heterophylla*
15. *M. s.* *Mnium stellare*
16. *P. l.* *Paraleucobryum longifolium*
17. *P. p.* *Plagiochila porelloides*
18. *P. c.* *Plagiomnium cuspidatum*
19. *R. p.* *Rhizomnium punctatum*
20. *T. d.* *Taxiphyllum densifolium*
21. *T. t.* *Tortella tortuosa*
22. *T. r.* *Tortula ruralis*

Nos 12 and 13 denote the same species but deriving from another population. B. r. denoted by Nos 3, 4 and 5 were collected from more places and included as separate samples. As values of $^{14}CO_2$ fixation fall close to each other, the average are given in a column.

From the plant communities formed on the diabase rocks of Szarvaskő (*Diantho-Seslerietum heuflerianae*, *Poetum pannonicae* and *Spiraeetum mediae*) the following bryophyte species (17) were tested:

23. *A. a.* *Abietinella abietina*
24. *B. a.* *Bryum alpinum*
25. *E. st.* *Encalypta streptocarpa*
26. *E. s.* *Eurhynchium swartzii*
27. *G. t.* *Grimmia trichophylla*
28. *H. l.* *Hypnum lindbergii*
39. *M. f.* *Mannia fragans*
20. *P. u.* *Plagiomnium undulatum*
31. *P. s.* *Pleurochaete squarrosa*
32. *P. pl.* *Porella platyphylla*
33. *R. s.* *Rhodobryum spathulatum*
34. *R. t.* *Rhytidiadelphus triquetrus*
35. *R. r.* *Rhytidium rugosum*
36. *S. g.* *Saelania glaucescens*
37. *Th. d.* *Thuidium delicatulum*
38. *T. i.* *Tortella inclinata*
39. *T. t.* *Tortella tortuosa*

Species (24) examined from the lichens of the "Primeval forest":

40. *A. c.* *Anaptychia ciliaris*
41. *C. f.* *Cladonia furcata*
42. *C. a.* *Collema auriculatum*
43. *C. c.* *Collema crispum*
44. *D. m.* *Dermatocarpon miniatum*
45. *E. p.* *Evernia prunastri*
46. *H. p.* *Hypogymnia physodes*
47. *P. a.* *Parmelia acetabulum*
48. *P. c.* *Parmelia caperata*
49. *P. el.* *Parmelia elegantula*
50. *P. e.* *Parmelia exasperatula*
51. *P. g.* *Parmelia glabra*
52. *P. sc.* *Parmelia scortea*
53. *P. s.* *Parmelia sulcata*
54. *Pe. c.* *Peltigera canina*
55. *Pe. h.* *Peltigera horizontalis*

56. *Pe. p.* *Peltigera praetextata*
57. *Pe. r.* *Peltigera rufescens*
58. *Ph. d.* *Physconia detersa*
59. *Ph. g.* *Physconia grisea*
60. *R. e.* *Ramalina evernioides*
61. *R. f.* *Ramalina fastigiata*
62. *R. p.* *Ramalina pollinaria*
63. *X. e.* *Xanthoria elegans*

The plants were cleaned from the lichens and placed in a humid environment for two days to be fully water-satured.

$^{14}CO_2$ fixations were carried out in the apparatus shown in Figure 1 (made similarly to the apparatus applied in the Institute of Plant Physiology of MTA Biological Centre of Szeged). Box (a) divided into four compartments belongs to this apparatus. In this box the test plants were arranged on plexilaminae. A reaction vessel (b), a cooling spiral (c) and a membrane pump (d) were connected to the box. After closing the box, between the listed parts a closed system is formed in which the circulation of gases is ensured by means of the membrane pump. The cooling spiral as well as the water basin (e) placed on the top of the box prevent the inner temperature caused by irradiation from rising.

Fresh leafy blades spears of bryophytes and thallus parts of lichens were placed on the lamellae covered by wet filter-paper. After closing the box the inactive and radioactive ($^{14}C$) $BaCO_3$ were washed in the reaction vessel (b) with dilute sodium hydroxide. Methyl red indicator was used. Carbon dioxide was released by perchloric acid. In the fixation system this resulted in the concentration four times higher than average. With such a high value, smaller fluctuations of $CO_2$ do not influence the photosynthesis considerably. Thus, $CO_2$ was regarded as a constant, stable factor at each measurement.

$CO_2$ release was followed by a fixation for a quarter of an hour in dark, then for an hour in light, meanwhile the gas mixture was continuously circulated by the pump. $CO_2$ fixation was stopped by the addition of 6N NaOH to the reaction vessel, which fixated $CO_2$ in 15 minutes. The test plants were dried with a warm iron and their radioactivity was established by means of gas analysis. After absorption on an alkaline absorbent, the activity of $^{14}CO_2$ obtained from burning was determined by a liquid-scintillation spectrophotometer. The obtained dpm values were given as reduced to dry weight mg $g^{-1}$ · $CO_2$ contents of the box were set to 0.12%-v/v. In this $CO_2$ radioactivity of u Ci $\mu mol^{-1}$ was developed. The $\mu$mol corresponding to u Ci obtained when measuring the radioactivity of the samples is expressed in mg. The calculations are presented in details, in the supplement (see: Supplement 1).
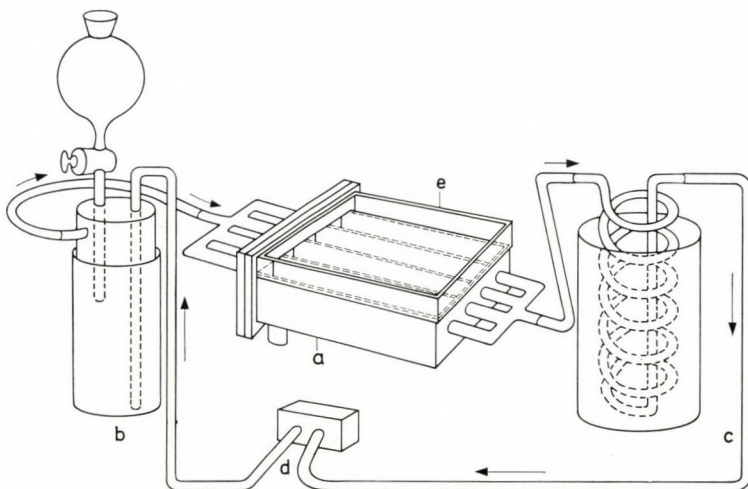
*Fig. 1.* Apparatus used for photosynthetic fixation of $CO_2$

Results can be considered as half quantitative, giving an appropriate ground for comparison. Errors of quantitative determination may derive from the isotope effect, a certain unpunctuality of measuring and fixating technique applied. It must be taken into consideration that during a fixation period of an hour there is an opportunity for the reassimilation of $^{14}CO_2$ to a lesser degree. Values obtained are next to the net photosynthesis. Voznesenskii suggested that Carbon-14 method should be regarded as independent from other ones e.g. from the "infra-red" gas analysis, even concerning its result, too.

## Results and evaluation

Fixation of $^{14}CO_2$ was carried out with bryophytes and lichens on July 20, 1980. Well cleaned, virulent spears of bryophytes were placed in the case and fixated under natural lighting at a light intensity of 9 thousand lux on 26 °C. Results are shown in Figs 2 and 3. Scatter values are larger in the fixation of $^{14}CO_2$ of the rock-bryophytes of Szarvaskő, but it is, however, due only to the extremely high value of *R. s.*, leaving this out of consideration, there is no significant difference in the photosynthesis of the species of the two niches. *Rhodobryum spathulatum* has a share of 30% in the $CO_2$ intake of
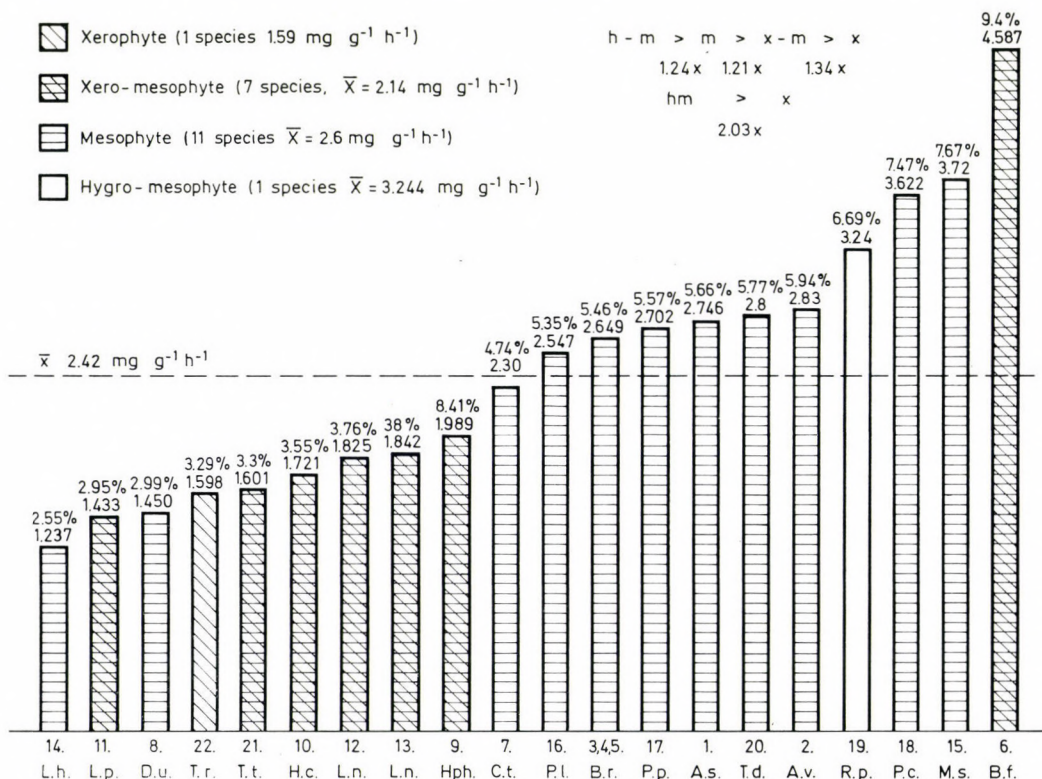
*Fig. 2.* Intake of $^{14}CO_2$ of the bryophytes of the "primeval forest" mg $g^{-1}h^{-1}$
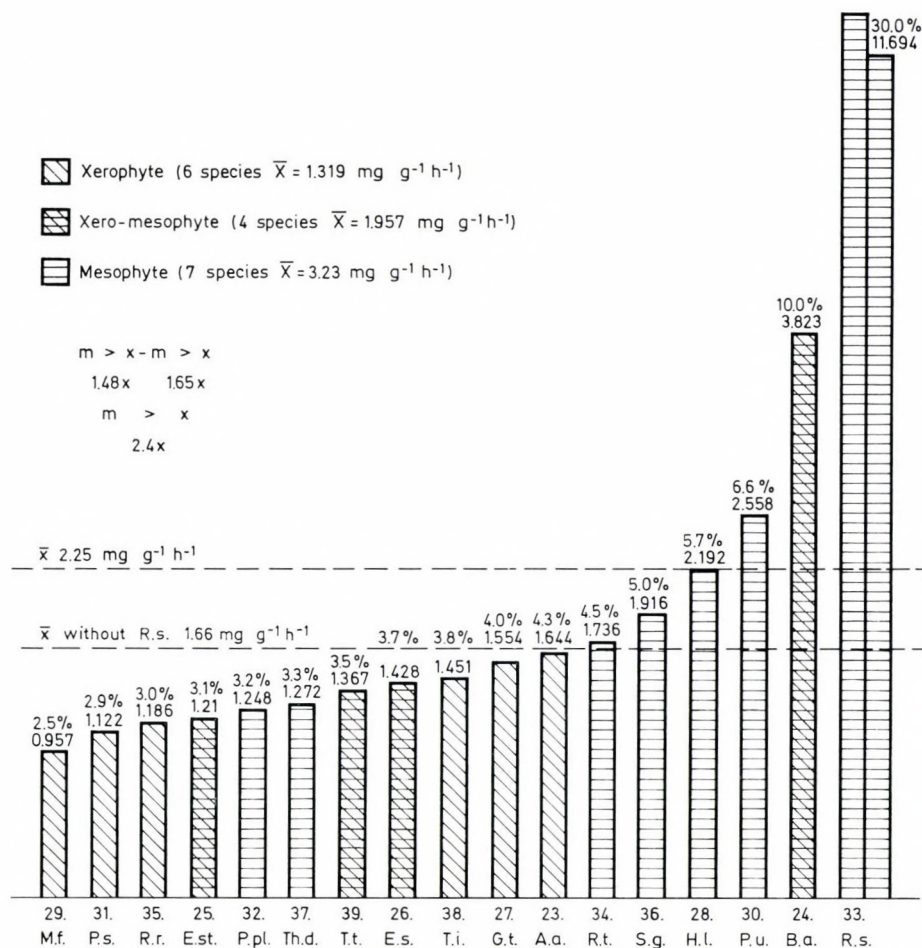
*Fig. 3.* Intake of $^{14}CO_2$ of the bryophytes of Szarvaskő mg $g^{-1}h^{-1}$

the 17 bryophyte species. A rather intensive photosynthesis is characteristic of the two *Bryum* species, *B. flaccidum* and *B. alpinum*, too. The average $^{14}CO_2$ fixation of the bryophytes of beech-wood falling to 1 species is higher by 4% than the productivity of the bryophytes of Szarvaskő. Disregarding the high value of *R. s.* the difference is 17% to the advantage of the bryophytes of beech-wood. Values relating to the $CO_2$ intake of four arctic bryophytes, made known by P. C. MILLER et al., are also in this range: 0.4 to 18 mg $CO_2$ $g^{-1}h^{-1}$. With our measurements optimal conditions of photosynthesis were achieved. According to RASTORFER (1968) it is to 30 °C (max. 41 °C, min. −5 °C) in some *Bryum* species. Light saturation of bryophyte species examined by him occurred already at 65 lux.

There was a remarkably close connection between the photosynthetic intensity of the species and their ecological character (Figs 2, 3). The quantity of $^{14}CO°$ fixation gradually increases from xerophytes towards hygrophytes. Between xerophytes and xero-mesophytes there is a difference of 1.65 and 1.34 times, respectively, while between xero-mesophytes and mesophytes a difference of 1.48 and 1.21 times, respectively. Hygro-mesophytes show a productivity 1.24 times larger than that of the mesophytes of the "Primeval forest". It can also be stated that species with larger, wider leaves — the majority of which is mesophyte and hygromesophyte at the same time — fixate more $^{14}CO_2$. Such are *Rhodobryum spathulatum*, *Mnium stellare*, *Plagiomnium cuspidatum*, *Rhizomnium punctatum*. Our finding has been confirmed also of data VITT and PAKARINEN (1977). Contents of carbon, nitrogen, ashes of the bryophytes examined by us as well as quantities of fractions dissolved in alcohol increase from the xerophytes towards the hygrophytes. This is evidently associated with their photosynthetic productivity.

With bryophytes, too, such as *Marchantia*, operation of glycolyte-oxidase enzyme was shown by NELSON and TOLBERT (1970). It was supposed that glycolyte metabolism may operate also with bryophytes, as in the leaves of vascular plants. This can be associated with the strong photorespiration of certain species, resulting in their high $CO_2$ compensation point. Slight $CO_2$ utilization, accordingly, decreases the photosynthetic productivity of the species. According to the measurements of RASTORFER (1968) *Drepanocladus uncinatus* has a high $CO_2$ compensation point. This is supported also by the result of our measurement, according to which the species has a very low fixation value being well under the average level.

The $^{14}CO_2$ fixation of the lichens of the "Primeval forest" was performed at a light intensity of 14 thousand lux, under natural light conditions. Before fixation the thalluses had been kept in a humid exsiccator in order to become saturated with water. Figure 4 illustrates the results where the columns were drawn in proportion to those illustrating the photosynthesis of the bryophytes (Figs 2, 3). Low values compared to the previous ones are remarkable even with a light intensity higher than 4 to 5 thousand lux. Average production of lichens is 5.2 times smaller compared to the average $^{14}CO_2$ fixation of the bryophytes. Results of our measurements resemble the data of LARSON et al., KERSHAW, SMITH and LECHOWICZ, respectively.

The chlorophyll contents of flowering plants, bryophytes and lichens were compared. Table 1 indicates that there is no substantial difference in the pigment contents of flowering plants and bryophytes. This also refers to their photosynthetic intensity. Pigment contents of lichens is 6 to 7 times less than that of the bryophytes, and this is connected with their productivity, which is 5 to 5.5 times less even in spite of the favourable light conditions.

A systematic study of the values of photosynthesis reveals that the
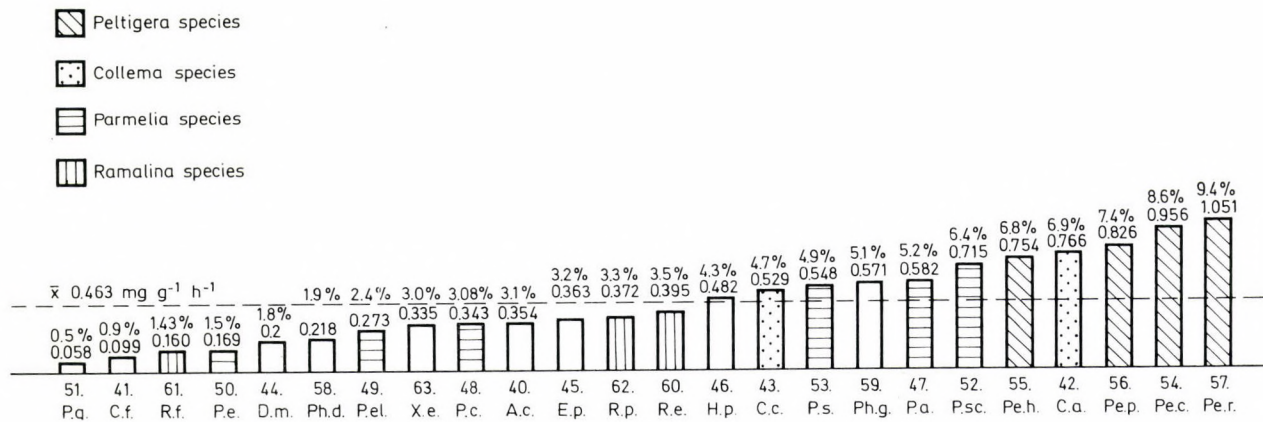
*Fig. 4.* **Intake of $^{14}CO_2$ of the lichens of the "primeval forest" mg $g^{-1}h^{-1}$**

**Table 1**

| Pigment | Chl a, mg g$^{-1}$* | | | Chl b, mg g$^{-1}$ | | | Chl a + b, mg g$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Taxons | mean | min. | max. | mean | min. | max. | mean | min. | max. |
| Flowering plants** (12 species) | 2.08 | 1.25 | 4.27 | 1.71 | 0.75 | 2.88 | 3.79 | 1.82 | 5.97 |
| Bryophytes*** (39 species) | 2.66 | 1.37 No. 18 P.c.[1] | 4.25 No. 36 S.g. | 1.67 | 0.93 No. 21 T.t. | 2.75 No. 35 R.r. | 4.33 | 2.66 No. 14 L.h. | 6.31 No. 36 S.g. |
| Lichens*** (4 species) | 6.8× V 0.39 | 0.34 | 0.49 | 7.95× V 0.21 | 0.20 | 0.21 | 7.21× V 0.60 | 0.55 | 0.70 |

* mg g$^{-1}$ (dry weight)
** Emőd, J. (1981)
*** Emőd, J., Suba, J. (1981) (species identical with those in the study)
**** Verseghy, K. (1972)

*Cladonia convoluta*
*Cladonia furcata*
*Cladonia magyarica*
*Parmelia pokornyi*
} On the basis of their value measured in the 7th month

[1] For abbreviations of species see p. 182—183.

stronger $^{14}CO_2$ fixation of *Peltigera* species was prominent. *Collema* species can also be mentioned here though not to the same extent. *Permelia* species, however, can be found in categories of each order. The higher values were characteristic of the species having blue algae (*Peltigera*, *Collema*).

Lechowicz and Adams (1979) pointed out that the various thallus-structures also influence net photosynthesis considerably by modifying $CO_2$ gas change. In connection with that we have established that species having a looser cortex and a more cavernous structure have higher productivity than the average value. This structure affords an opportunity for faster intake of $CO_2$, and the $CO_2$ to be concentrated in the inner spaces and for its reassimilation.

## Summary

On the basis of $^{14}CO_2$ fixation photosynthetic values were established of the bryophytes of the beechwood and rock plant communities. Larger differences were found in the intensity of photosynthesis of species living under more extreme microclimatic conditions. The average value was higher with beechwood species of more balanced microclimate. Photosynthetic activity is lowest with xerophytes and it gradually increases towards the hygrophytes. Species having larger, wider leaves fixate more $^{14}CO_2$.

Among lichens a stronger photosynthetic activity of the *Peltigera* species manifests itself as a systematic feature. The blue alga component as well as the looser cortex and more

cavernous inner structure also resulted in a higher productivity. Generally it can be stated that bryophytes have a photosynthetic intensity similar to that of flowering plants, while the lichens productivity is 5 times lower than these.

## Supplement No. 1

### Order of the calculations applied

1. Adjustment of the value of radioactivity and the $CO_2$ concentration in the air-space of the photosynthetizing box.
2. Establishment of the $CO_2$ quantity taken-up from the radioactivity of the samples (cpm).

### 1.a. Adjustment of $CO_2$ concentration

It was our object to produce the quadruple, 0.12% v/v, of the average $CO_2$ concentration of the atmosphere by $CO_2$ released from $BaCO_2$.

To perform this, approx. 0.03 per cent concentration of $CO_2$ already prevailing in the air was also taken into consideration, therefore $CO_2$ corresponding to 0.09 per cent had to be developed.

The volume of the photosynthetizing system box + reaction vessels + tubes is 2100 ml, in which $CO_2$ needed for developing a 0.09 per cent concentration, expressed in ml, is: 0.09% conc. in 100 ml corresponds to 0.09 ml of $CO_2$

in 2100 ml $x$

$x = 1.89$ ml of $CO_2$

The quantity of $BaCO_3$ needed for producing 1.89 ml of $CO_2$

24.000 ml of $CO_2$ develops from 197 g of $BaCO_3$
1.89 ml of $CO_2$ develops from $x$

$x = 15.5$ mg of $BaCO_3$

In the air $CO_2$ corresponds to 5.3 mg of $BaCO_3$. Consequently, there is an amount of $CO_2$ corresponding to 20.8 mg of $BaCO_3$ in the total.

### 1.b. Adjustment of radioactivity value

Our aim was to create an atmosphere of 1 $\mu$ Ci $\mu mol^{-1}$ $CO_2$. In the photosynthetizing system there is a quantity of $CO_2$ to be developed from 20.8 mg of $BaCo_3$, expressed in ml:

197 mg of $BaCO_3$ 24 ml of $CO_2$
20.8 mg of $BaCO_3$ $x$

$x = 2.53$ ml of $CO_2$

Expressed in mol:

24 ml of $CO_2$ 1 m mol
2.53 ml of $CO_2$ $x$

$x = 0.105$ m mol $= 105$ $\mu$mol

Adjustment of the radioactivity of 1 $\mu$ Ci $\mu mol^{-1}$: How much $^{14}CO_2$ is to be released from $Ba^{14}CO_3$ of special activity of 290 $\mu Ci\ mg^{-1}$ to obtain $CO_2$ of 105 $\mu$mol.

290 $\mu$Ci is in 1 mg of $Ba^{14}CO_3$
105 $\mu$Ci is in $x$ $Ba^{14}CO_3$

$x = 0.362$ mg of $Ba^{14}CO_3$

Consequently, if $CO_2$ is released from 0.362 mg of $Ba^{14}CO_3$ and 15.5 mg of $BaCO_3$, then, some 0.12 per cent concentration of $CO_2$ with a radioactivity of 1 $\mu$Ci (37 kBq) $\mu mol^{-1}$ is obtained in the photosynthetizing system.

**2. Establishment of the taken-up quantity of $CO_2$ from the radioactivity of the samples (cpm value)**

a. Reduction of cpm to dpm:

$$dpm = \frac{cpm - background\ s}{efficiency}$$

b. Reduction of dpm to $\mu$Ci and kBq, respectively

$$\mu Ci = \frac{dpm}{2.22 \times 10^6}$$

$$kBq = \mu Ci \times 37$$

c. Reduction of $\mu$Ci value to $\mu$mol and mg
In case of a radioactivity of 1 $\mu$Ci $\mu mol^{-1}$
1 $\mu$Ci value corresponds to $CO_2$ of 1 $\mu$mol.
1 $\mu mol = 44 \times 10^{-3}$ mg of $CO_2$

Quantity of $CO_2$ taken up during the photosynthesis, expressed in mg = the obtained value of $\mu Ci \times 44 \cdot 10^3$.

Values were related first to the weight of dry material of the measured sample, then to a unit weight (g).

Concrete measurement from $Ba^{14}CO_3$: e.g. 0.583 mg, this corresponds in the given system to a radioactivity of $\frac{0.583}{0.362} = 1.61$ $\mu$Ci $\mu mol^{-1}$.

Radioactivity of the sample was e.g. 98 $\mu$Ci $g^{-1}$ (dry material), which, expressed in mg, is:

A radioactivity of 1.61 $\mu$Ci belongs to $CO_2$ of 1 $\mu$mol
98 $\mu$Ci $x$

$x = CO_2$ of 60.869 $\mu$mol

$CO_2$ of 1 $\mu$mol 0.044 mg
$CO_2$ of 60.869 $\mu$mol $x$

$x = 2.6782$ mg of $CO_2$

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# MEIOSIS IN ANTHER-DERIVED POLYHAPLOID OF NICOTIANA INTERSPECIFIC HYBRID

L. Szilágyi

RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

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In the course of our previous studies using *Nicotiana* species we managed to produce the alloploid hybrid *N. tabacum* (Kentucky) × *N. glauca* with 2n = 48 chromosome number. We proved that the hybrid plants contain the whole *Nicotiana glauca* genom, while there was a partial chromosome elimination in *N. sylvestris* and *N. tomentosiformis* genoms. After segregations during the subsequent generations it can be considered in its recent form as a highly stable alloploid species hybrid. The regularity of its meiotic process has also been proved by producing 2n = 2x = 24 type polyhaploid plants. The resulting polyhaploid plants showed a stable phenotype, i.e. similarly to the original hybrid plants they had white flowers. The *N. tabacum* (Ky) × *N. glauca* 2n = 2x = 24 itself showed an irregular meiosis which has led us to conclude that there is only a minimal homology in the three genoms of the plants (S′T′G′).

## Introduction

Nowadays haploid callus, embryo and even whole plants can be obtained by inducing in vitro androgenesis in anther cultures (Reinert and Bajaj 1977). However, pollen-breeding can not be considered as a routine procedure in many species. In anther cultures plants with ploidity levels other than haploid could also be found quite often. Among the *Nicotiana* species in anther cultures of *N. otophora, N. sylvestris* and *N. tabacum* haploid, diploid and even tetraploid plants could be selected (Collins and Sadasivaiah 1972). The frequency of the occurrence of a polyploid is most variable and it depends on the time of anther isolation (Engvild et al. 1972).

Haploids obtained from interspecific hybrids have scarcely been reported in the literature. Guo (1972) using anther cultures of interspecific hybrids raised haploid callus of *N. suaveolens* × *N. langsdorffii* and Smith (1974) produced that of *N. glauca* × *N. langsdorffii*, but they were not always successful in regenerating whole plants from the calluses.

In order to analyse the genetical system regulating the incompatibility, D. de Nettacourt and Devreux (1977) have proposed producing haploid plants from hybrids of autocompatible and autoincompatible tomato species. The hybrid plants have various combinations of mother and father derived chromosomes, and thus the formation of different substitution lines is a possibility.

Our earlier results showed that the caryotype (n = 24) and the isoenzyme pattern of the polyhaploid (allopolihaploid) plants obtained from the anther culture of *N. tabacum* (Ky) × *N. glauca* (2n = 48) were identical with the properties of the hybrid with original chromosome number 2n = 48 (Szilágyi and Nagy 1978). The formation of "haploid" plants with 2n = 2x = 24 chromosome number has proved the regularity of the meiotic process of the original alloploid hybrid.

The results summarized in this paper deal with the meiosis of *N. tabacum* × *N. glauca* polyhaploid and provide further data concerning the genom homology of the *Nicotiana* species.

## Material and methods

Polyhaploid and allopolyhaploid plants were produced by using *N. tabacum* (Kentucky) × *N. glauca* alloploid hybrids with decreased chromosome number (2n = 48) according to the method of NITSCH and NITSCH (1969). The plantlets obtained from anthers were kept during our experiments on a culture medium containing mineral nutrients in a controlled chamber at +25 °C (SZILÁGYI and NAGY 1978). The rooted plantlets were kept under greenhouse conditions until flowering.

Meiotic investigations were carried out by using the acetocarmine method. Pollen fertility was judged by the proportion of stainable (acetocarmine) and non-stainable ("empty") pollens (SZILÁGYI 1975).

Microphotographs were taken with MF Zeiss apparatus set up on an NFpK 2 research microscope (magnification: 10 × 100).

## Results

The flow diagram of the procedure followed in our experiments is shown in Fig. 1 This paper summarizes the results of the last section of this experimental scheme.

12 polyhaploid of *N. tabacum* (Ky) × *N. glauca* raised to flowering were morphologically uniform with exceptionally narrow leaves and white flowers (Fig. 2). According to our previous observations the somatic cells of these plants had 24 chromosome (SZILÁGYI and NAGY 1978).

The microphotographs of meiotic chromosomes are show in Fig. 3. Due to the presence of a higher genom number, the meiosis of polyhaploids should be theoretically more regular than that of the monoploids. Our experimental plants have three genoms: the genom of *N. sylvestris* — *N. tomentosiformis* and — *N. glauca* (STG). The homology in these three genoms is minimal, therefore univalents were most frequently formed as it can be seen in Fig. 3.

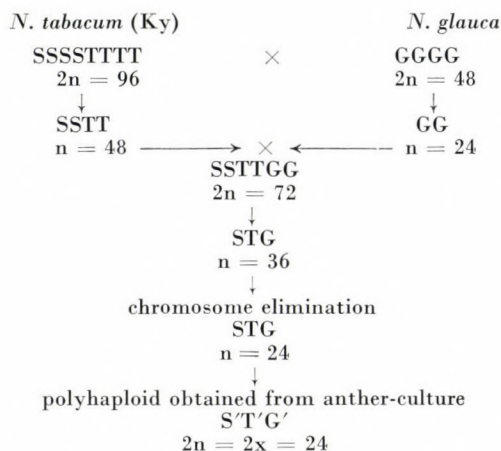
Figs 3a and 3b show cells with a few univalents in the first metaphase of the meiosis. However, this type of cell could be found at a low frequency. A late metaphase can be seen

S = *N. sylvestris*, T = *N. tomentosiformis*, G = *N. glauca*.

*Fig. 1.* Diagram of the experiment

*Fig. 2.* Plant of polyhaploid *N. tabacum* × *N. glauca*

in Fig. 3c where chromosomes are arranged into three groups suggesting a possible segregation of the three genoms (STG).

In Figs 3d and 3c a partial chromosome pairing with two bivalents can also be observed, while 3f and 3g show unequal chromosome division in anaphase I. All pollens of the examined plants were sterile (Fig. 3h) and these plants did not produce seeds.

## Discussion

Development in the technique of tissue cultures enabled producing haploid plants from anthers. By using this method we could reduce the chromosome number in the *N. tabacum* (Ky) × *N. glauca* alloploid hybrid produced by us. According to the meiotic analysis (SZILÁGYI 1975) the original alloploid plant had $2n = 48$ chromosomes, while the polyhaploid contained $n = 24$ ones. Thus, by producing polyhaploid plants we could prove that the original alloploid plants have regular meiosis.

By investigating the polyhaploid meiosis of *Nicotiana* we obtained more information about the homologies of the genoms of *N. sylvestris*, *N. tomentosiformis* and *N. glauca*.

Haploid plants usually have irregular meiosis. However, the orientation of all chromosomes can happen accidentally around one pole in the first

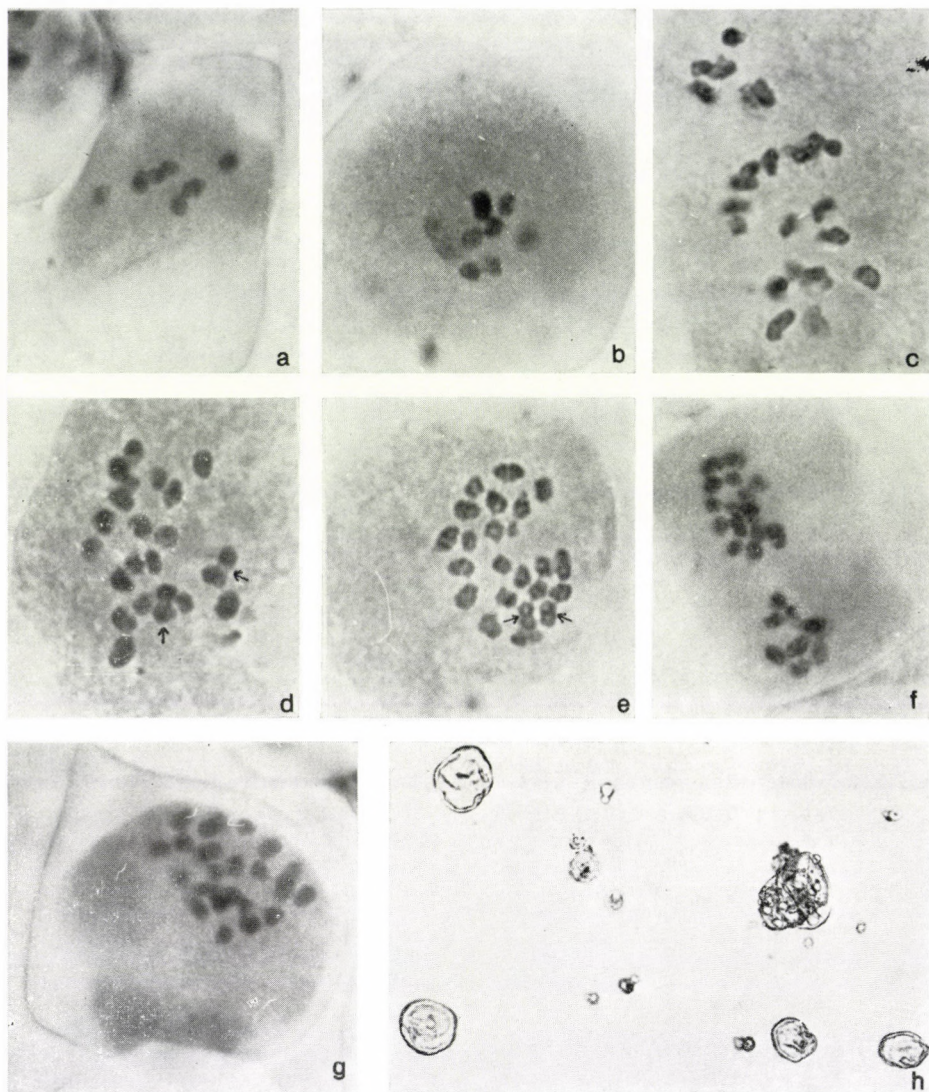



*Fig. 3.* Meiosis of polyhaploid *N. tabacum* × *N. glauca* (2n = 2x = 24). *a–b.* Meiosis in the polyhaploid plant showing decreased numbers of chromosomes (univalents). *c.* The first meiotic metaphase showing a tendency of genom segregation. *d–e.* The first meiotic metaphase with univalents and only two bivalents. *f–g.* The first meiotic anaphase with various chromosome distributions. *h.* Sterile pollen grains of polyhaploid plant

anaphase and thus a viable gamete can be produced. The fusion of such male and female gametes will result in diploid plants. This, so-called spontaneous rediploidization occurs very rarely, depending on the species, at only a few thousandth frequency.

In our previous investigations we observed the spontaneous rediploidization of the haploid *N. sylvestris* (SZILÁGYI 1975). The allopolyhaploid obtained from species hybrids *N. tabacum* (Ky)×*N. glauca* contains three genoms (S′T′G′), therefore the formation of several bivalents can be theoretically expected in the meiosis. This seemed to be most probable because according to data of different literature in *N. tabacum*×*N. glauca* species hybrid $0\text{–}4_{III}$, $3\text{–}10_{II}$, and in *N. tabacum*×*N. sylvestris* species hybrid $3_{III} + 9_{II} + 9_{I}$ trivalent, bivalent and univalent have occurred (TANAKA 1953, KOSTOFF 1943). These homologous or homoeologous chromosomes can be paired.

In the polyhaploid produced by us the low frequency of bivalent occurrence can be explained by the fact that the experimental plant contains the whole *glauca* genom but a partial chromosome elimination happened in the *tomentosiformis* and *sylvestris* genoms in the course of the segregations accomplished during subsequent generations (SZILÁGYI 1975).

In the *glauca* genom and in the remaining genoms of the two progenitors the chromosomes are not homologous. As a result of this, in the first anaphase of the polyhaploid meiosis the univalents are accidentally distributed between the two poles. It can happen rarely that all chromosomes are concentrated around one pole, i.e. the reduction in chromosome number did not take place (Fig. 2g) and thus the formation of unreduced gametes could be expected. There is however, only a little chance that the unreduced male and female gametes would fuse. This was indicated by the total sterility of the plants. Similarly to this, in our previous experiments *N. tabacum* var. petit Havana polyhaploid line turned out to be sterile (MALIGA and SZILÁGYI 1973).

In opposition to this, polyhaploids reported in the literature showed a regular meiosis. Almost full chromosome pairing was observed for example in polyhaploids of *Capsicum*, *Dactylis*, *Medicago*, *Solanum*, *Bromus* and *Sorghum* species or in trihaploids of *Triticum aestivum* where there is three times more chromosome pairing than in the monohaploid of *Aegilops longissima* (SUTKA 1980).

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# DEVELOPMENTAL MORPHOLOGY OF *ARMENIACA VULGARIS* LAM. (ROSACEAE)

By

J. SZUJKÓ-LACZA

BOTANY DEPARTMENT OF THE HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST, HUNGARY

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The outer- and inner morphology of the convarieties "C-235 Magyar kajszi" and "C-778 Rózsabarack" of the *Armeniaca vulgaris* LAM. are described from the seedling to the mature fruit. Length of petiole, base of leaves, width and width per length of leaf lamina changes from the first to the last, i.e. to the apex. Flowering buds are grouped mainly on the dwarf twigs of the two-year-old branches and at the base of the one-year-old one. The flower has a double calyx tube. The inner one is formed from the receptacle and the lower part of the filaments, and these compose the nectariferous area. Within the seed at first a nutritive tissue (endosperm) developes which subsequently disappears parallel with the development of the embryo. Shape index of the fruit of C-235 is 0.94–1.12, and 1.35 of C-778.

## Introduction

Two convarieties of apricot are cultivated in Hungary in a large arable field. They are sold on the domestic market as fresh fruit, canned food, jam and brandy but a considerable quantity is exported as well (≈2000 t/year). This fruit is very popular in South and South-East Eurasia, and is cultivated in large fields; its native habitat might presumably be in this area (cf. NYUJTÓ and TOMCSÁNYI 1959). Apricot is grown in a rather wide-ranging area of the western part of Europe as well.

The apricot *Armeniaca vulgaris* LAM. (previously named *Prunus armeniaca* L.) belongs to the *Prunoideae* subfamily of *Rosaceae* family of the *Rosales* order as a species of the *Armeniaca* genus.

The best specified description of *Armeniaca vulgaris* LAM. was given by KOSTINA (1936) but excellent reviews have been written by Hungarian agriculturists as well (NYUJTÓ and TOMCSÁNYI 1959, BRÓZIK 1960, etc.). However, descriptions of the same organs, e.g. leaf shape, teeth, etc. are often quite dissimilar (cf. MÁNDY 1948). The development and the chronological changes are either not described or the descriptions refer only to a single organ. The authors (KOSTINA 1936, LÖSCHNING and PASSACKER 1954, NYUJTÓ and TOMCSÁNYI 1959, BRÓZIK 1960) have examined the morphology, size and colour of the mature fruit in more detail than the other organs.

But no study has dealt with for example the development of the fleshy fruit, stone fruit, and seed together. Description of two convarieties, No. C-235 = Magyar kajszi, and No. C-778 = Rózsabarack of *Armeniaca vulgaris* LAM. is given in this paper.

## Material and method

The investigations were started on August 5, 1977, with convarieties of C-235, C-244, C-612, C-703 and C-778 gathered on the farm of the Horticultural and Fruit Producing Research Institute in Cegléd. The next year the number of convarieties were reduced to C-235 and C-778 since most data in the literature referred to them.

Selection of samples started on April 11, 1978, by collecting flowering shoots. The collection of branches of the same "sample" trees was repeated approximately every fourteen days until the ripening of the fruit (cf. Table 4). Shoots of the same branches were sorted as apical-, lateral- and dwarf-twigs. Measurements of the length of the shoot and its diameter at the base and apex were taken. Starting at the base of the shoot, length of the petiole and the leaf-blade or lamina as well as the width of the leaf-blade were measured. In the course of their development, the shape of the base and apex of the leaf was recorded. The length/width (cf. HICKEY 1973) as well as width/length ratios were calculated. The value of the width/length ratio was taken between 0 and 1 so it makes calculation easier (cf. Table 1).

When examining the inflorescence, first the size of the flower next to the base of the shoot was taken — just like for the leaves. Length of the calyx and sepal-teeth, length and breadth of petal and length of the pistil and ovary are given in millimetres in the blossoming developmental phase. The number of stamens was also counted (Table 2).

Width and length of the fruit were measured along the raphe and perpendicularly to this level, length and width of the stone fruit and its hole were taken separately along the plane of the raphe, and length and width of the seed and the embryo of 3 fruits of each (sort) sample were measured at the same time.

Based on the average value, form or shape index $A_i = \frac{L^2}{D \cdot W}$ of the immature fruit was calculated according to LÖSCHNING and PASSACKER (1954) the relative growth rate = RGR was calculated according to BLACKMAN (1919). Where $L = \frac{a}{2}$ = radius of fruit parallel with the raphe; $D = \frac{b}{2}$ = radius of the fruit perpendicular to the raphe; $W = \frac{c}{2}$ = radius of the width of fruit. To obtain the value of RGR, first the cubic of the fruit was calculated on the basis of model

$$\frac{4}{3} abc = \frac{x^2}{a^2} = \frac{y^2}{b^2} = \frac{z^2}{c^2} = 1$$

which approximates an ellipsoid fruit-shape; "$a$" and "$b$" means the length (cut along the raphe and perpendicularly to that plane), while "$c$" means the width. Variability of the cubic in $m^3$ of the fruit was considered as a characteristic feature of the development of the fruit so model of RGR value was

$$\mathrm{RGR} = \frac{\log_2 V_2 - \log_2 V_1}{t_2 - t_1},$$

where $V = \mathrm{mm}^3$, $t_2$ and $t_1$ means the space of time between two measurements expressed in days (KVĚT et al. 1971).

Only two dimensions (length and width) of the size-changing of the ovary hole, the ovary and the embryo were dealt with, they are expressed in $\mathrm{mm}^2$.

The shape index of the mature fruit was also computed, but for the sake of comparability, the thickness = $v$, width = $sz$, length = $h$ (along the raphe) of 17 pieces of C-235 and 23 pieces of C-778 convarieties are considered here. These data, calculated with the ellipse equation, approach reality (cf. LÖSCHNING and PASSACKER 1954) but only by using a modifying constant = $k$. To obtain the value of "$k$", 27 specimens of C-235 and 30 specimens of C-778 were taken separately in a measuring-tube of 1000 ml each, then the measuring-tubes were filled with water to the meniscus. Pouring into another measuring tube, water quantity above the apricot volume was measured. The cubic content of 27 as well as the 30 apricots had been obtained from the difference of the two measurements. The cubic content of one apricot was obtained by taking the average of the two values, so $x = \frac{n}{1000 - m}$; where $n$ = number of fruit; $m$ = amount of water in the measuring tube above and among the fruits. The quotient of the measured and calculated cubic volumes became the "$k$" value characterizing the convarieties: $k = 1.24$ for C-235, $k = 1.10$ for C-778.

To calculate the shape index of the mature fruit, data of stone fruits each were used.

## Results and discussion

### *Seedling*

### Radicula

In the germination process the radicula arose at the apex of the stone fruit (Fig. 1). A top root and numerous lateral roots developed from the radicle. The direction of the top root depends on the soil structure in which the germination takes place. Lateral roots are approximately at right angles to the top roots. The top root is colourless-white and subsequently becomes nut-brown, and the lateral ones are of a faint white colour.

### Plumule

Between the root and the cotyledons a shorter or longer hypocotyl develops and above the cotyledons the epicotyl and the plumule. The length of the epicotyl depends on the thickness of the soil on the seed. The colour of the cotyledons is often red, they are ovate and wider at 2/3 length, the base subsequently narrows. The stone fruit and seed coat adhere to the cotyledons (Fig. 2) for a long time.

The angle of cotyledons and epicotyl is larger in C-235 than in C-778 (Figs 3, 4).

*Fig. 1.* Radicula of the apricot in the apex of the seed. Around the seed there is the stone-fruit (Photo: I. RÁCZ)
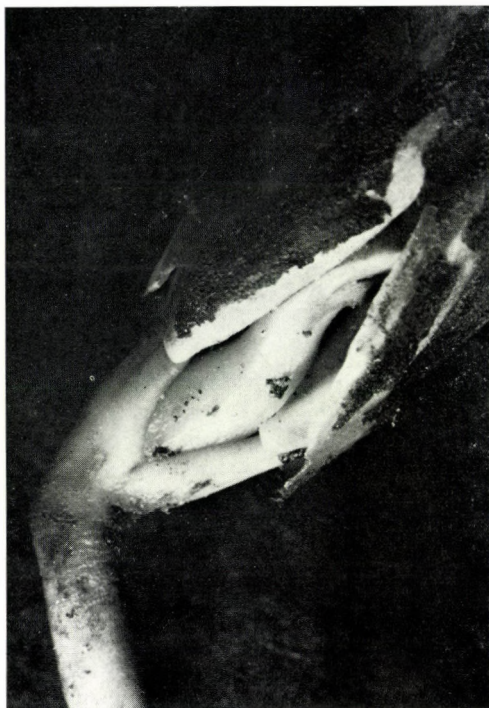
*Fig. 2.* Plumula between the cotyledons, enveloped by seed-coat (Photo: I. RÁCZ)

## Seed plant

After the plumule emerges in a month or so, more stipule and foliage leaves develop on the stem of the seed plant while the cotyledons are in good swollen condition (Figs 3, 4). The initial leaves are scutellate-like bracts in spiral or alternate arrangement (Figs 3, 4). The length of the first leaf petiole is 3–4 mm, the lamina is typically apricot leaf like. The base of the leaf is decurrent. The lamina is 5 mm long and 1.5 mm wide. The length of the petiole of the fourth leaves is 5 mm, the lamina length is 7 mm and the width is also 5 mm. The petiole of the sixth leaf is 5 mm long, the length and width of the lamina are 7 mm each. The base is decurrent, the margin is serrate. According to HICKEY (1973) these serrate teeth belong to type 1A. The teeth are convex on both sides. Petioles of leaf No. 14 are 5 mm long. The length of the lamina is 36 mm and the width is 26 mm. The base of the leaf is cordate, the apex asymmetric. In MÁNDY's (1949) opinion this type of leaf apex is broadly acuminated. The venation are pinnatiformis craspedodromous. The seed plant is weak in C-778 as in C-235 (Figs 3, 4).

*Fig. 3.* Almost three-months-old seedling of the C-235 (Photo: I. RÁCZ)

## *Trees*

## Root system

The seedlings and the seed plants grow (Figs 1, 3, 4) and develop with top root. But the cultivated trees have a lateral root system lying shallow in the soil (BRÓZIK 1960) (Fig. 5). The surface of the lateral roots is violet coloured (cf. PASSACKER in: LÖSCHNING and PASSACKER 1954).

## Branch system

The diameter of the canopy increases from 6 to 12 m (cf. BRÓZIK 1960, LÖSCHNING and PASSACKER 1954 and Fig. 6). Trees are 3 to 17 m high according to KOSTINA, the average value being 5 m according to SOKOLOV (1954). The diameter of tree-trunk is usually 20 or
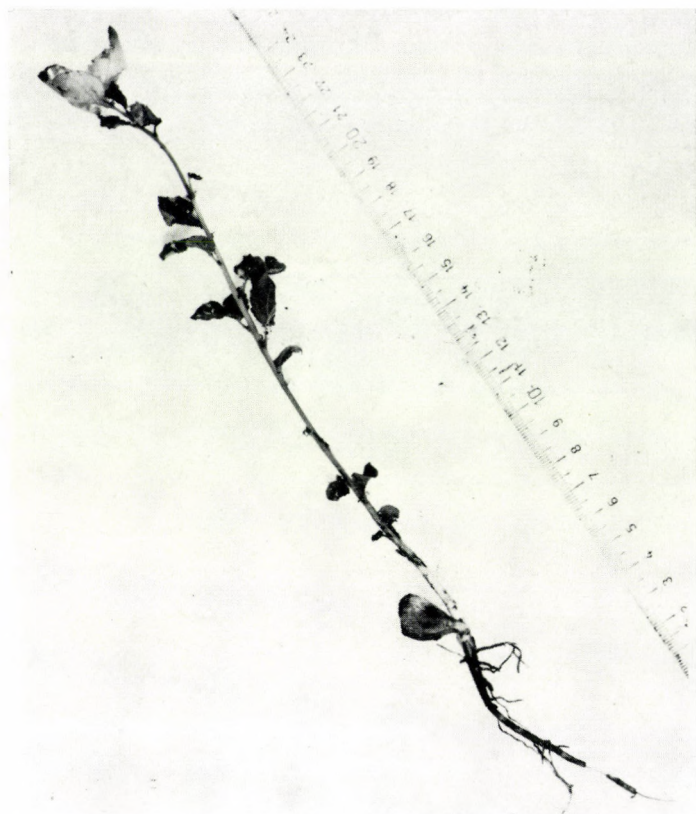
*Fig. 4.* Almost three-months-old seedling of C-778 (Photo: I. RÁCZ)

*Fig. 5.* The well-developed lateral root without top root of the apricot tree (Photo: D. KOVÁTS)

*Fig. 6.* The sample tree of C-235 in blossom (Photo: D. Kováts)

30 cm but the oldest ones reach even 60 cm. The trunk is spirally twisted (Fig. 7). The cork is thin and becomes shaky in a young tree and deformed on the oldest one (Fig. 8). The surface of the cork is verrucose (Fig. 14). The old cuticula layer remains on the cork sporadically, these patches are greyish white, the other patches of the cork are dark red or reddish-brown. The canopy is made up of widespread branches, hemispherical, half-dense in "Magyar kajszi" (Fig. 6) whereas the "Rózsabarack" differs a little bit from this form.

The understock is very often the "Tengeri" or "Majombarack" in Hungary. Its thin and short branches rise upwards from the thick and relative horizontal branches (Fig. 9). One of the best apricot of the future is the "Velasquez" (Fig. 10). The branches are long, growing rapidly, but fragile. The *Armeniaca vulgaris* has monopodial branches, but the form

*Fig. 7.* The apricot tree trunk growing in spiral form (Photo: D. Kováts)

*Fig. 8.* Cork-surface of apricot tree (Photo: D. KOVÁTS)

of the cultivated trees is modified by pruning. The twigs and branches of the convarieties of *Armeniaca vulgaris*, C-235 Magyar kajszi and C-778 Rózsabarack, are awnless and bright grey by the cuticle (Fig. 11). Under the layer of the cuticle the cork is red.

The vegetative buds are axillary, and they grow in lateral and terminal positions (Fig. 11). They are always smaller than the flower buds. The angle of divergence of the main axis and lateral buds of C-235 is 40–60° and 30–40° of C-778. According to BRÓZIK (1960) the buds of C-235 are fitted to the main axis, middle-broad, spindle-like and the buds of C-778 curved to the main axis and narrow-spindle like (Fig. 11). The leaf- and flower-bud scales are arranged in double spirals helically, covered by the shoot and flower primordia.

*Fig. 9.* "Tengeri" or "Majom" apricot (Photo: D. KOVÁTS)

*Fig. 10.* "Velasquez" sort (Photo: D. Kováts)

The outer-lower perules are the biggest and become gradually smaller toward the apex of the bud (Fig. 11). The buds-scale is symmetric, sectors form at the base, and obtuse at the apex, dark-brown or black in colour. The inners has three yellowish-green leaflets and fall off after developing the cauline leaves. The margin is weakly tomentose. The leaves are in a twisted form in the buds (cf. Kostina 1936).

The long branches grow as a relative main axis on the stem after some years. On these large branches the lateral and terminal branches develop. Usually two terminal branches grow which are of unequal length. The dwarf twigs (Fig. 12) often occur on the long branches (Figs 13, 13a) and rarely on the large and bulky branch Tomcsányi (in: Nyujtó and Tomcsányi 1959). In relation to the fruit production, two types of branches may be differentiated. One is that of the long branches and the other is the dwarf branches. According to Nyujtó and Tomcsányi (1959) the dwarf branches are not longer than 10 cm, and bear vigorous flower buds. They can be further classified according to these short branches: *a)* the leafless fructiferous branch (Fig. 12), and *b)* one or two leaves on the fructiferous branch (Fig. 12). This latter may be one or two years old or more. They differ in age and length, but are often grouped in the two-year-old part of the long branches (Fig. 13). These distributions of the dwarf branches influence the distribution of fruits in the canopy. Childers (1973) divided it into several layers according to the frequency distribution of apple in the canopy. The apple tree canopy produces in the first or outer layer. In the apricot canopy the second one is the more producing layer. Because the fructiferous branches = dwarf branches, occurs in a relative

*Fig. 11.* Spindle-like buds of C-778 (Photo: I. RÁCZ)

short part of the two-year-old or older branch and some more flower buds are situated near the base of the one-year-old branch. These latter flower buds occurred on both sides of the vegetative bud at the base of the one-year-old branch and only on the one side of the vegetative bud toward the apex of this branch (Fig. 13a).*

The architecture of the leaf canopy is influenced by the different types of branches and twigs and also by the angles the branches form with each other (Figs 9, 10).

Between the relative main branches and long lateral branch this angle of divergence is 30° in C-235 and 40° in C-778. The oldest branches are usually at 50° to each other.

* This phenomenon is characteristic also of *Prunus domestica*, *P. persica*, *P. spinosa*.
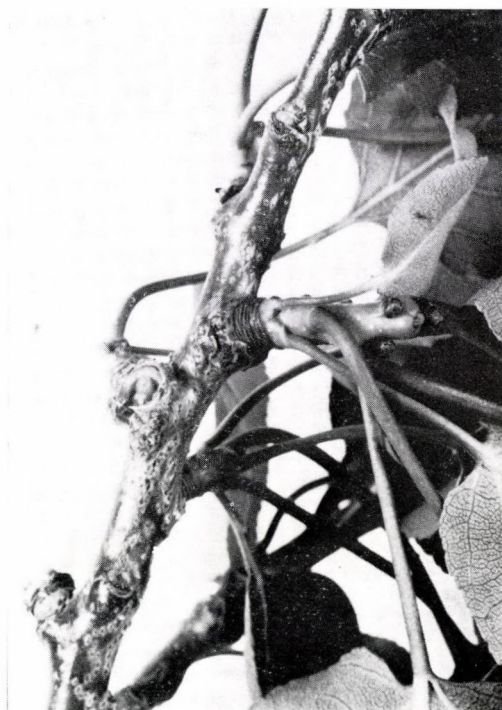
*Fig. 12.* Differences among the dwarf twigs on the branch (Photo: I. Rácz)

Sokolov (1954) made a new classification also according to the frequency of the dwarf branches (i.e. fertile branches). The frequency distribution of the different branches and twigs of C-235 and C-778 are shown in Table 1.

Accordingly, a five-year-old branch of the C-235 has three long shoots or long lateral branches, two apical branches and one dwarf branch. On these five-year-old branches new branches occur at a 50 mm average distance with the exception of the apical branches. The long lateral branches bear more dwarf shoots. So, e.g. the second longest branch has three dwarf branches and the average distance is 83 mm between the two twigs.

A three-years-old branch of C-778 is 220 mm long, with three long lateral and dwarf branches.

The branches and twigs are arranged on the relative main branches in double spirals.

## *The growth rhythm of the branches in a vegetation period*

The first and considerable growing phase is in May and the second one is in June by the "jánosnapi" ("day of John") shoots. Both kinds of apricots finish the long growing phase of the branches in June, or July. Löschning and Passacker (1954) investigated the growth in the "Nancy" variety from 4 of July until 20 in 1941. The results of his measurements have shown that the dwarf branches grow linearly and the absolute value of the long growth of the lateral and long branches are represented by a curve. The vegetative axillary buds arose in C-778 at the beginning of July and in C-235 at the end of July.

## Table 1

C-235

*Branches, leaves*

| Type of shoot | Branch | | | | | Leaves | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. | Length | Ø of branch at the base | Ø of branch at the apex | Number of leaves | Serial No. | Length of petiole (in mm) | Length of lamina (in mm) | Width of lamina (in mm) | L/W | W/L | Shape of shoulder | Shape of apex |
| 5 years-old branch | 1. | 200 | 10 | 5 | | | | | | | | | |
| lateral branch | 1. | 90 | 4 | 2 | 6 | | without measurement | | | | | | |
| lateral branch | 2. | 241 | 8 | 2 | 9 | 1. | 11 | 17 | 9 | 1.88 | 0.53 | ovate | symmetric |
| | | | | | | 2. | 15 | 25 | 17 | 1.47 | 0.68 | rounded | asymmetric |
| | | | | | | 3. | 15 | 43 | 40 | 1.07 | 0.93 | cordate | asymmetric |
| | | | | | | 4. | 30 | 55 | 45 | 1.22 | 0.82 | cordate | asymmetric |
| | | | | | | 5. | 35 | 67 | 53 | 1.26 | 0.97 | cuneate | asymmetric |
| | | | | | | 6. | 35 | 70 | 57 | 1.23 | 0.81 | cuneate | asymmetric |
| | | | | | | 7. | 37 | 77 | 59 | 1.30 | 0.77 | cuneate | asymmetric |
| | | | | | | 8. | 42 | 78 | 64 | 1.21 | 0.82 | decurrent | asymmetric |
| | | | | | | 9. | 45 | 85 | 67 | 1.26 | 0.79 | decurrent | asymmetric |
| dwarf twig | 1. | 10 | 3 | 2 | 4 | 1. | 8 | 16 | 12 | 1.33 | 0.75 | ovate | asymmetric |
| | | | | | | 2. | 17 | 35 | 30 | 1.10 | 0.86 | cordate | asymmetric |
| | | | | | | 3. | 34 | 60 | 58 | 1.03 | 0.79 | cuneate | asymmetric |
| | | | | | | 4. | 40 | 73 | 58 | 1.25 | 0.79 | cuneate | asymmetric |
| dwarf twig | 2. | 24 | 4 | 2 | 6 | 1. | without measurement | | | | | | |
| | | | | | | 2. | 14 | 37 | 28 | 1.32 | 0.75 | cordate | symmetric |
| | | | | | | 3. | 30 | 57 | 43 | 1.32 | 0.75 | cuneate | symmetric |
| | | | | | | 4. | 28 | 70 | 48 | 1.45 | 0.68 | cuneate | asymmetric |
| | | | | | | 5. | 40 | 70 | 50 | 1.40 | 0.70 | cuneate | asymmetric |
| | | | | | | 6. | 30 | 60 | 54 | 1.29 | 0.90 | cuneate | asymmetric |
| | | | | | | — | — | — | — | — | — | — | — |
| dwarf twig | 3. | — | — | — | 2 | — | — | — | — | — | — | — | — |
| lateral branch | 3. | 260 | 7 | 3 | 9 | 1. | 9 | 15 | 14 | 1.07 | 0.93 | ovate | asymmetric |
| apical branch | 1. | 280 | 7 | 2 | 13 | 2. | 12 | 23 | 16 | 1.43 | 0.69 | ovate | asymmetric |
| | | | | | | 3. | 18 | 35 | 30 | 1.10 | 0.85 | cordate | asymmetric |
| | | | | | | 4. | 22 | 45 | 37 | 1.21 | 0.82 | cordate | asymmetric |
| | | | | | | 5. | 30 | 58 | 50 | 1.10 | 0.86 | cordate | asymmetric |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 6. | 32 | 55 | 52 | 1.05 | 0.94 | rounded | symmetric |
| | | | | | | 7. | 22 | 61 | 47 | 1.29 | 0.77 | cuneate | asymmetric |
| | | | | | | 8. | 40 | 73 | 56 | 1.30 | 0.78 | cuneate | asymmetric |
| | | | | | | 9. | 35 | 78 | 58 | 1.34 | 0.74 | cuneate | asymmetric |
| | | | | | | 10. | 42 | 82 | 70 | 1.17 | 0.85 | decurrent | asymmetric |
| | | | | | | 11. | 45 | 78 | 65 | 1.20 | 0.82 | decurrent | asymmetric |
| | | | | | | 12. | 47 | 90 | 70 | 1.28 | 0.77 | decurrent | asymmetric |
| | | | | | | 13. | 48 | 90 | 68 | 1.30 | 0.75 | decurrent | asymmetric |
| dwarf twig | 1. | 6 | 3 | 2 | 5 | 1. | without measurement | | | | | | |
| | | | | | | 2. | 12 | 28 | 22 | 1.27 | 0.79 | ovate | asymmetric |
| | | | | | | 3. | 20 | 42 | 31 | 1.35 | 0.74 | cordate | symmetric |
| | | | | | | 4. | 27 | 52 | 44 | 1.18 | 0.85 | cuneate | symmetric |
| | | | | | | 5. | 30 | 60 | 47 | 1.28 | 0.78 | cuneate | asymmetric |
| dwarf twig | 2. | 4 | 2 | 2 | 2 | 1. | 12 | 29 | 20 | 1.45 | 0.69 | ovate | asymmetric |
| | | | | | | 2. | 27 | 46 | 36 | 1.28 | 0.78 | ovate | asymmetric |
| dwarf twig | 3. | 20 | 4 | 3 | 7 | 1. | 7 | 18 | 12 | 1.50 | 0.67 | ovate | asymmetric |
| | | | | | | 2. | 10 | 22 | 16 | 1.38 | 0.73 | ovate | asymmetric |
| | | | | | | 3. | 26 | 48 | 39 | 1.23 | 0.81 | cordate | asymmetric |
| | | | | | | 4. | 30 | 58 | 47 | 1.23 | 0.81 | cordate | asymmetric |
| | | | | | | 5. | 35 | 63 | 48 | 1.31 | 0.76 | cuneate | symmetric |
| | | | | | | 6. | 38 | 72 | 51 | 1.41 | 0.71 | cuneate | asymmetric |
| | | | | | | 7. | 40 | 76 | 50 | 1.52 | 0.66 | cuneate | symmetric |
| dwarf twig | 4. | 3 | 2 | 1 | 3 | 1. | 14 | 26 | 21 | 1.24 | 0.81 | ovate | asymmetric |
| | | | | | | 2. | 33 | 50 | 42 | 1.19 | 0.84 | cordate | asymmetric |
| | | | | | | 3. | 40 | 60 | 50 | 1.20 | 0.83 | cuneate | symmetric |
| dwarf twig | 5. | 6 | 2 | 2 | 5 | 1. | 4 | 14 | 7 | 2.00 | 0.50 | ovate | symmetric |
| | | | | | | 2. | without measurement | | | | | | |
| | | | | | | 3. | 22 | 44 | 32 | 1.38 | 0.73 | cordate | symmetric |
| | | | | | | 4. | 27 | 53 | 41 | 1.29 | 0.77 | cuneate | asymmetric |
| | | | | | | 5. | 40 | 71 | 52 | 1.37 | 0.73 | cuneate | asymmetric |
| dwarf twig | 6. | 6 | 2 | 2 | 5 | 1. | 8 | 15 | 12 | 1.25 | 0.80 | ovate | symmetric |
| | | | | | | 2. | 17 | 32 | 25 | 1.28 | 0.78 | cordate | symmetric |
| | | | | | | 3. | 25 | 48 | 41 | 1.25 | 0.80 | rounded | symmetric |
| | | | | | | 4. | 35 | 60 | 47 | 1.28 | 0.78 | cuneate | asymmetric |
| | | | | | | 5. | 42 | 69 | 51 | 1.35 | 0.74 | cuneate | asymmetric |
| dwarf twig | 7. | 3 | 1 | 1 | 3 | 1. | 10 | 25 | 12 | 1.08 | 0.48 | ovate | symmetric |
| | | | | | | 2. | 23 | 45 | 34 | 1.32 | 0.76 | cordate | asymmetric |
| | | | | | | 3. | 37 | 70 | 46 | 1.52 | 0.66 | cuneate | symmetric |

| Type of shoot | Branch | | | | | Leaves | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. | Length | ∅ of branch at the base | ∅ of branch at the apex | Number of leaves | Serial No. | Length of petiole (in mm) | Length of lamina (in mm) | Width of lamina (in mm) | L/W | W/L | Shape of shoulder | Shape of apex |
| dwarf twig | 8. | 2 | 1 | 1 | 2 | 1. | 23 | 37 | 27 | 1.37 | 0.73 | cuneate | asymmetric |
| | | | | | | 2. | 35 | 55 | 40 | 1.38 | 0.73 | cuneate | asymmetric |
| dwarf twig | 9. | 7 | 2 | 1 | 5 | 1. | without measurement | | | | | | |
| | | | | | | 2. | without measurement | | | | | | |
| | | | | | | 3. | 22 | 46 | 39 | 1.18 | 0.85 | cordate | asymmetric |
| | | | | | | 4. | 32 | 62 | 48 | 1.29 | 0.77 | cuneate | asymmetric |
| | | | | | | 5. | 40 | 76 | 56 | 1.36 | 0.74 | cuneate | asymmetric |
| apical branch | 2. | 220 | 8 | 2 | 11 | | without measurement | | | | | | |
| C-778 | | | | | | | | | | | | | |
| three years-old branch with 3 lateral 2 apical branch + lateral branch | 1. | 115 | 8 | 6 | | | without measurement | | | | | | |
| ,, | 2. | 120 | 4 | 3 | 17 | 1. | 7 | 17 | 11 | 1.55 | 0.65 | cuneate | asymmetric |
| | | | | | | 2. | 12 | 16 | 13 | 1.23 | 0.81 | cuneate | asymmetric |
| | | | | | | 3. | without measurement | | | | | | |
| | | | | | | 4. | 20 | 34 | 26 | 1.31 | 0.76 | cuneate | asymmetric |
| | | | | | | 5. | 25 | 36 | — | — | — | — | — |
| | | | | | | 6. | 18 | 33 | 28 | 1.18 | 0.85 | cuneate | asymmetric |
| | | | | | | 7. | 32 | 45 | 36 | 1.25 | 0.80 | decurrent | asymmetric |
| | | | | | | 8. | 30 | 47 | 40 | 1.18 | 0.85 | decurrent | asymmetric |
| | | | | | | 9. | 31 | 45 | 36 | 1.25 | 0.80 | decurrent | asymmetric |
| | | | | | | 10. | 34 | 57 | 44 | 1.25 | 0.80 | decurrent | asymmetric |
| | | | | | | 11. | 45 | 70 | 56 | 1.30 | 0.77 | decurrent | asymmetric |
| | | | | | | 12. | without measurement | | | | | | |
| | | | | | | 13. | without measurement | | | | | | |
| | | | | | | 14. | without measurement | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 15. | 35 | 68 | 64 | 1.06 | 0.94 | decurrent | asymmetric |
| | | | | | | 16. | 42 | 72 | 70 | 1.03 | 0.97 | decurrent | asymmetric |
| | | | | | | 17. | 38 | 72 | 66 | 1.09 | 0.92 | decurrent | asymmetric |
| apical branch from this the "jánosnapi" part is 96 mm long | 1. | 115 | 5 | 2 | 13 | 1. | without measurement | | | | | | |
| | | | | | | 2 | 15 | 30 | 15 | 2.00 | 0.50 | cordate | symmetric |
| | | | | | | 3. | 23 | 38 | 28 | 1.36 | 0.74 | rounded | symmetric |
| | | | | | | 4. | 22 | 42 | 31 | 1.35 | 0.74 | cuneate | symmetric |
| | | | | | | 5. | 25 | 46 | 43 | 1.35 | 0.74 | cordate | symmetric |
| | | | | | | 6. | 25 | 47 | 40 | 1.18 | 0.85 | cuneate | asymmetric |
| | | | | | | 7. | 30 | 45 | 39 | 1.15 | 0.87 | cuneate | asymmetric |
| | | | | | | 8. | 32 | 53 | 44 | 1.20 | 0.85 | decurrent | asymmetric |
| | | | | | | 9. | 29 | 45 | 34 | 1.32 | 0.76 | cordate | asymmetric |
| | | | | | | 10. | 37 | 51 | 41 | 1.24 | 0.80 | cuneate | asymmetric |
| | | | | | | 11 | 32 | 56 | 48 | 1.17 | 0.86 | cuneate | asymmetric |
| | | | | | | 12. | 32 | 49 | 46 | 1.07 | 0.94 | cordate | asymmetric |
| | | | | | | 13. | 34 | 57 | 50 | 1.14 | 0.88 | cuneate | asymmetric |
| apical branch | 2. | 45 | 4 | 3 | 12 | 1. | 10 | 20 | 12 | 1.67 | 0.60 | ovate | asymmetric |
| | | | | | | 2. | 15 | 26 | 16 | 1.63 | 0.62 | ovate | asymmetric |
| | | | | | | 3. | 22 | 36 | 27 | 1.11 | 0.90 | cordate | symmetric |
| | | | | | | 4. | 18 | 30 | 22 | 1.36 | 0.73 | cordate | symmetric |
| | | | | | | 5. | 24 | 35 | 27 | 1.22 | 0.77 | rounded | asymmetric |
| | | | | | | 6. | 32 | 46 | 43 | 1.07 | 0.93 | rounded | asymmetric |
| | | | | | | 7. | 35 | 49 | 44 | 1.11 | 0.90 | cuneate | asymmetric |
| | | | | | | 8. | 31 | 47 | 43 | 1.09 | 0.91 | cuneate | asymmetric |
| | | | | | | 9. | 38 | 56 | 52 | 1.08 | 0.93 | cuneate | asymmetric |
| | | | | | | 10. | 30 | 53 | 40 | 1.33 | 0.75 | decurrent | asymmetric |
| | | | | | | 11. | 38 | 63 | 52 | 1.21 | 0.83 | decurrent | asymmetric |
| | | | | | | 12. | 30 | 53 | 44 | 1.20 | 0.83 | decurrent | asymmetric |
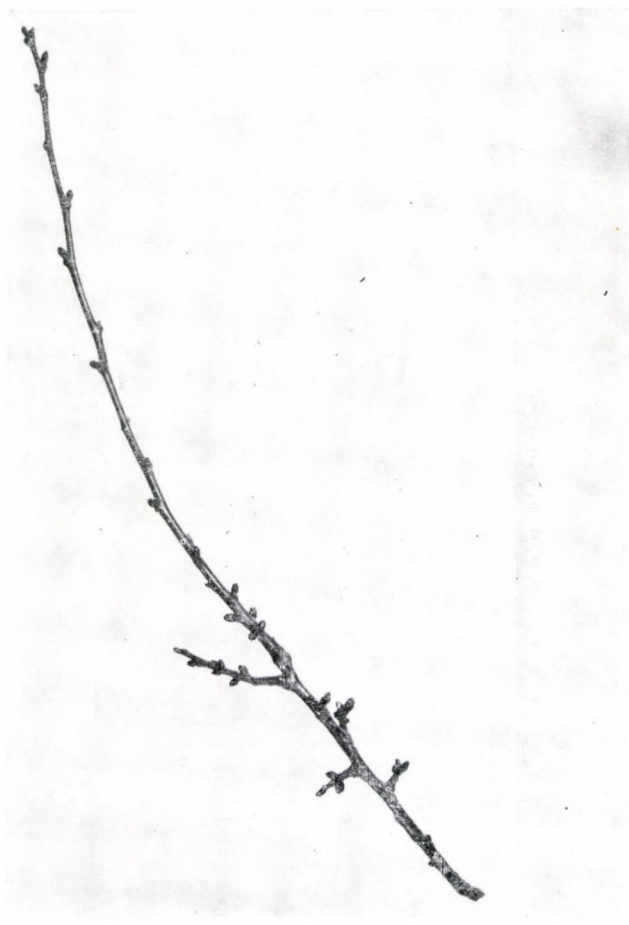
*Fig. 13.* Two-years-old branch with dwarf twigs bearing the reproductive buds (Photo: I. RÁCZ)

*Fig. 13a.* The second or reproductive layer of the branch. Part from the Fig. 13

*Fig. 14.* Leaves with different length of petiole in a "one-year-old" branch of C-235 cv. (Photo: D. KOVÁTS)

## *Leaves*

The spirally or alternately arranged leaves develop from the vegetative bud in early spring with the new part of the branches and twigs. The new leaves develop in the apex of the shoots in early spring and in the middle of summer.

## Petiole

The leaves are petiolate (Figs 14, 16). The petiole grows wider at the base. The petiole is scaphoid (Fig. 15) and dark red. This colour is continued in the midrib of the lamina. The petiole is sparsely pubescence, there are rudimentary bracts and nectar glands on the surface (Fig. 15). The number of bracts and nectar glands is higher on the leaves that develop in the middle of the summer. According to DOBOS (1975), the number of nectar glands on the petiole is higher in August. The length of the petiole depends on the serial number of the leaf and the position of the leaf on the stem (Figs 14, 17, 18a–b, 19a–c, and Table 1). The nectar glands of the petiole belongs to the extranuptial ones (CASPARY 1848, BONNIER 1879, FILARSZKY 1911, EWERT 1932, LENGYEL 1943, NYÁRÁDY 1958, GULYÁS 1975). These glands were classified by their form, too (DELPHINO 1886, ZIMMERMANN 1932, GULYÁS 1964).

The nectar glands of the different species and varieties of the Hungarian cultivated fruit trees were studied intensively by MOHÁCSY (1954), MOHÁCSY and MALIGA (1956), BRÓZIK (1960).

*Fig. 15.* Nectar glands of the schaphoid petiole of C-235 (Photo: I. RÁCZ)

GULYÁS (1964) counted those plant families which are the source of nectar without flowers (extranuptial ones). Accordingly, numerous species of 55 families are known which have extranuptial glands in Hungary. The importance of the opinion for these species were discussed by LABANCZ (1912), HALMÁGYI and SUHAJDA (1963), GULYÁS (1975), and PÉTER (1975) detail. Taking into consideration the developmental time of the extranuptial glands, they are not connected with the fertilization of flowers because these latter develop much earlier. The biological role of the extranuptial nectar glands are unknown.

DOBOS (1975) claims that, after finishing their secretion, these glands are modified like bracts. The transformation of these glands and their venation system show the leaf origin of the glands (GULYÁS 1964).

The nectar glands of the petiole of the apricot, *Prunus mahaleb* (*Cerasus mahaleb*), *Amygdalus persica* (*Prunus persica*), all of them species of *Rosaceae*, were studied anatomically by BONNIER (1879).

## The lamina

The dorsiventral lamina of the leaf are thick and coriaceous. The dorsal surface of the lamina is smooth and shiny. C-235 is darker green than C-778.
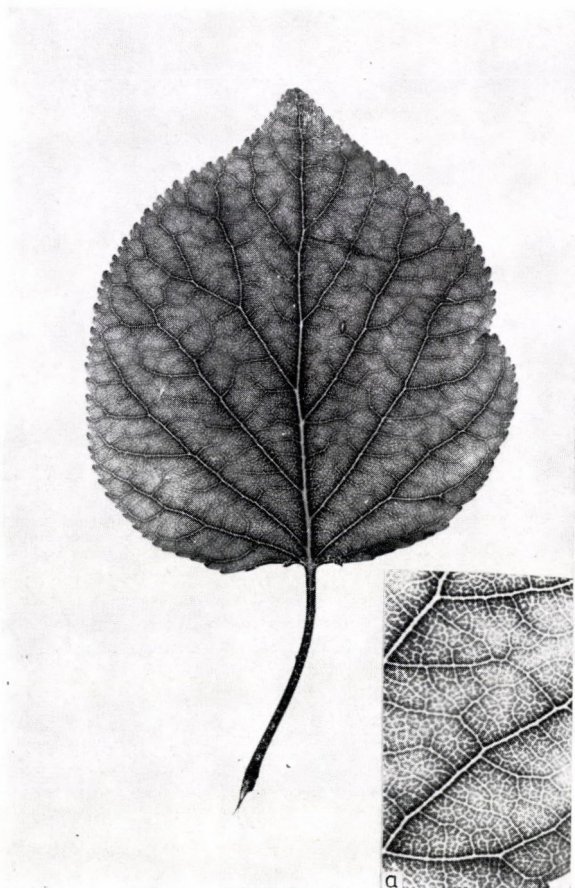
*Fig. 16.* Leaf lamina with (pinnatiform) craspedodronous venation. The teeth of the leaf differ from each-other from the base of leaf to the apex (Photo: I. RÁCZ)
*Fig. 16a.* One, two or three vein endings in a mesophyll chamber = intercostal area (Photo: I. RÁCZ)

The base of the leaves (Table 1) differ from the first to the last. Usually ovate, cordate, rounded or truncate, cuneate and decurrent base form follow one another in a row (Figs 14, 17). The form of the leaf base is in accordance with KRENKE's law (1940). According to this law, the form or size of the leaves, or both, change in order of the ontomorphogenetical age. Such changes are due to the physiological age of the plant. KRENKE regards ageing as a progression towards maturity, particularly reproductive maturity, which is sometimes followed by further cyclic changes. At points along this progression rejuvenescence may occur, as on shoots grown from lateral buds. Successive nodes are units in a developmental scale, and the form of the leaf is a qualitative criterion of physiological age.

It should be noted that most authors (KOSTINA 1936, SOKOLOV 1954, MÁNDY 1949, PÉTER 1975) usually mention only the cordate and decurrent form of the leaf base of apricot.
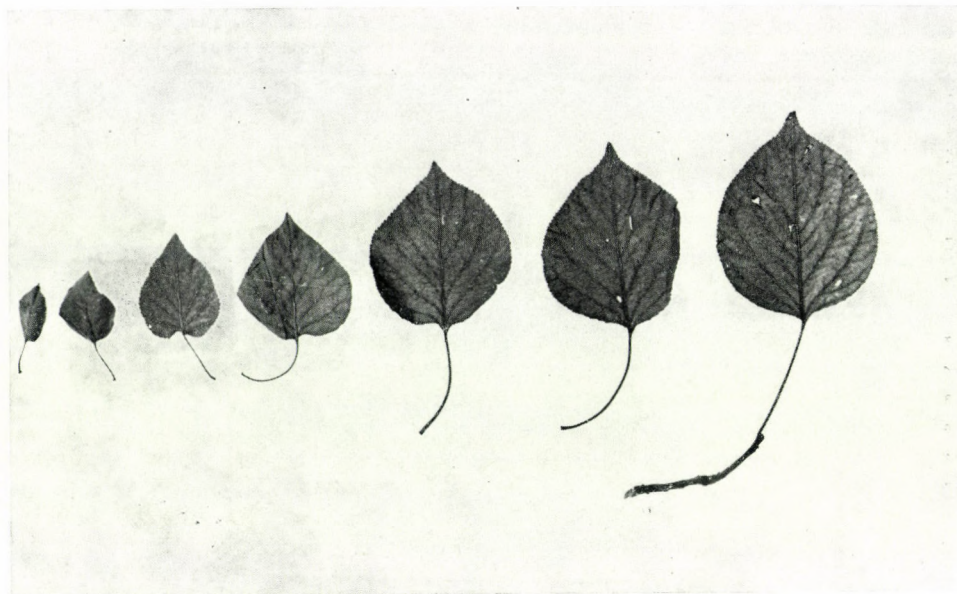
*Fig. 17.* The base and the area of the leaves differ from each-other from the first to the last e.g. the top leaf, according to Krenke's law (Photo: I. RÁCZ)

## The apex of the leaf is asymmetric

The margin of the leaf is serrate. The teeth of the leaf are narrow at the base of the lamina (Fig. 16) and convex in the middle (Fig. 16). According to HICKEY (1973), these types of teeth belong to the 4A and the 1A categories, respectively, on the same leaf. (In the opinion of some authors MÁNDY 1949, NYUJTÓ and TOMCSÁNYI 1959) the margin of the apricot leaf is crenate. The apex of the teeth often ends in the nectar gland (Fig. 16). This phenomenon is characteristic of most of the taxons of the *Rosaceae* family (cf. METCALFE and CHALK 1950).

## Venation

The venation is pinnatiformis craspedodromous, often ramifying at the margin. These vein endings finish in the apex of the serrate teeth (Figs 16, 17).

From the base to the leaf apex the angle of divergence between the midrib and the lateral veins changes by 5°, 5°, 8°, 8°, 7°, 5° in cuneate and 5°, 7°, 7°, 8° in decurrent base leaves. The subsequent vein ramifications are simple. In one intercostal area = mesophyll chamber (FEKETE and SZUJKÓ-LACZA 1973) there are one, two or three vein endings (Fig. 16a).

BRÓZIK (1960) considers it a characteristic feature of the leaf lamina whether it is scaphoid or not in the one-year-old sampling. This phenomenon may be in connection with the density of the samplings in cultivation and in case of the developed trees overshaded by the branches.

Data of different branches, and leaves of C-235 and C-778 with differences according to the age of the branches and leaves as well as to their architecture are given in Table 1. The older branches are thick but shorter than the apical branches. The dwarf branches are very different in connection with their age, the number of leaves belong to one old branch.
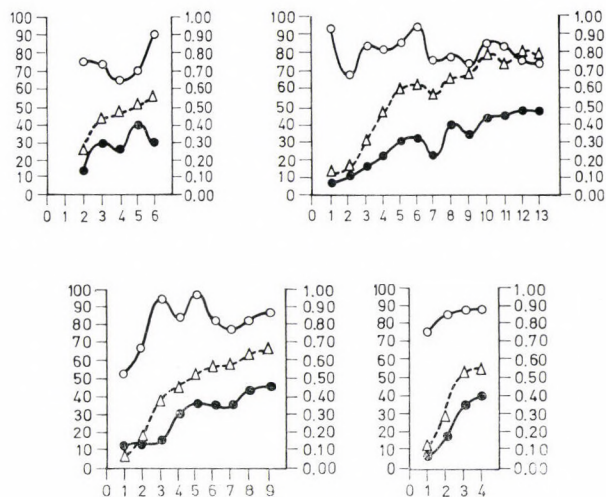
*Fig. 18.* The length of petiole, the extreme width of leaf blade, the width/length ratio of leaf blade on different branches and twigs of the C-235 Magyar kajszi (*Armeniaca vulgaris*). Length of petiole ●———●; extreme width of leaf blade ×--×; width/length of leaf blade ○———○ (The length of petiole and the width of leaf are measured on the $x$ axis in decimal scale; on the $y$ axis there a the serial number of leaf and on the $z$ axis are measured the width/length of leaf from 0.00–1.00.) *a)* The 2nd lateral branch of a 5-years-old one. *b)* The 1st twig. *c)* The 2nd twig. *d)* The 1st terminal branch
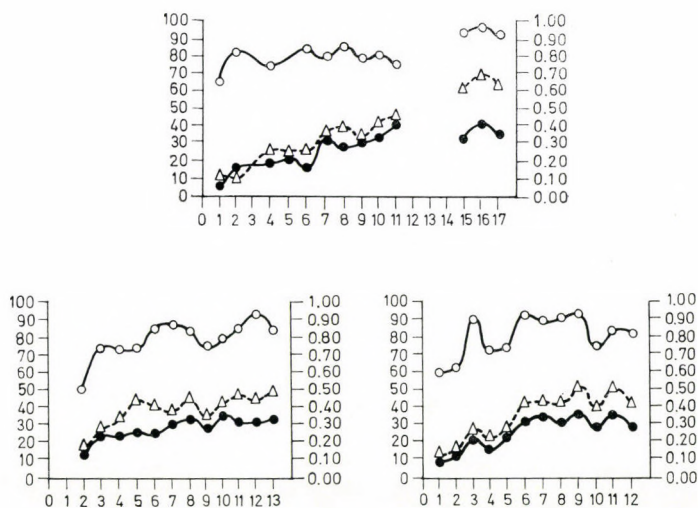
*Fig. 19.* The length of the petiole, the extreme width of the leaf blade, the width/lenght of the leaf blade on different branches and twigs of C-778 Rózsabarack. *a)* The 2nd lateral branch of a three-years-old one. *b)* The 1st terminal branch of the three-years-old one. *c)* The 2nd terminal branch of the three-years-old one

The length of the petiole of leaves changes and increases unequally from the first to the last apical leaf. But differences can be seen between the leaves of the branches and dwarf twigs.

In Table 1 there are data of 16 branches and twigs from which two were lateral branches, three apical and eleven dwarf branches of the C-235 and C-778 convarieties of apricot. The length of the petiole of leaves is showing an asymmetric sinusoidal curve of the long lateral and apical branches with the exception of the dwarf branches or twigs leaves (Figs 3, 13, 14, 17, 18a, 18d, 19a, b, c). The petiole increases almost regularly from the first to the last leaf in dwarf branches (Figs 18b, c).

The length of petiole curves fitted well to the curves of width of the leaf lamina, and the width/length ratio of lamina in the long lateral and apical branches (Figs 18a, d, 19a, b, c). The changes of the three curves (i.e. length of petiole, width of leaf lamina and the ratio of the width/length ratio of the lamina) are reflected by the change of the lamina's base of the leaves developed acropetally on the shoot. The length of petiole and the width of the same leaf lamina in the first two leaves usually have similar values, except on the first dwarf twigs of the first apical branches.

Researchers prefer to measure the length/width of the leaf, also in the "Ambrosia" convariety of apricot. These values are similar to the Hungarian C-235 and C-778 apricots. Therefore, this value may be a species character and probably less characteristic of the different varieties of the apricot.

The changes of the leaf lamina's base on a branch are sometimes irregular, especially in the "jánosnapi" part of the shoots (e.g. C-778, see Table 1).

The asymmetry of the leaf apex is not uniform and regular, probably it is due to the distribution of the leaf on the stem and the activity of auxin in the leaf.

## *Inflorescence*

The flower buds are also axillary but they are larger than the vegetative buds (Fig. 13) and the flower buds are always slightly on the side of the branch or twig compared with the vegetative buds (Figs 26, 27). The perules of the flower buds always open earlier than those of the vegetative buds (Fig. 22). The solitary flower buds are situated on the side of the oldest branches and also on the lower (basal) part of the one-year-old apical branches. The latter is usually withered. Flower buds develop in singles (Fig. 20), in pairs, or in groups of three or four, or the flower and vegetative buds develop mixed (Fig. 22).

Both types of buds develop in the preceding year, according to Solohov (1972) this process begins in April and finishes in June. Development of buds is followed by a rest period.

This resting period of the apricot buds was studied in detail by Brown and Kotob (1957) and Solohov (1970, 1972). According to Solohov this resting period is relative since the development of the micro-archeosporium takes place during this time.

Nyujtó and Babainé (1957) studied the development of the pollen grain of apricot in Hungary. Accordingly, the temperature of the winter months is higher than 3–5 °C, the pollen mother cells evolve at the beginning of January, the tetrads in the first week of February and the pollen grains full of starch in the last decade of March. Investigating the flower buds of peach and apricot Jelmanov (cf. Solohov 1970) had similar results. Jelmanov distinguished 6 phenophases in the development of peach and apricot buds:

I. Development of flower primordia. The calyx, corolla stamens and pistil primordias evolved in acropetal order.
II. Development of archeosporium in the anthers.
III. Meiotic division in the anthers.
IV. One-celled pollen grains.

V. Two-celled pollen grains.
VI. Blossoming time.

According to Brózik et al. (1968) blossoming of C-235 and C-778 started on 10 April in 1976, and lasted 7 and 9 days, respectively. In 1977 this process started on 25 March and lasted 5 and 6 days, respectively. Brózik (1960) investigated 32 convarieties of Hungarian apricot; he noticed that the blossoming time usually begins at the end of March and may last to the end of April. Under warmer climates the blossoming period of apricot may begin in December or January.

This large fluctuation of the blossoming time (beginning and duration) and the behaviour of the reproductive organs are in close connection with the precipitation and the temperature (Berezenko 1966, Bespecel'naja 1967, Nyujtó and Tomcsányi 1959, Molnár and Stollár 1971, Brózik and Nyéki 1975, Nyéki, Brózik and Ifju 1974a, b, Nyujtó and Banainé 1974). Studies of the frost resistance of apricots are also important for the agriculturist. According to Sokolov (1954) the intensity of development is directly connected with the hardiness. The development is the least intensive in the micro-archeosporial phase (cf. Jelmanov). This phase is the most frost resistant. Based on the examination of 150 convarieties of apricot he found that the flower buds are not damaged in −14 °C if they are in the micro-archeosporial phase. Frost resistance of buds decreases at an advanced developmental phase.

*Fig. 20.* Reproductive and vegetative buds of C-235 (Photo: I. Rácz)

*Fig. 21.* Shoot in blossoming phase. The perules covering the vegetative buds are very close (Photo: I. RÁCZ)

## *Flower*

The bisexual flower is pentacyclic, pentamerous, actinomorphic, with a shorter pedicel in the C-235 and a longer one in C-778. Flower organs originate in the (hyphanthium) receptacle.

The basic architecture of the flower of other apricots convarieties is the same, but they differ in size (Fig. 23).

Two-thirds of the calyx are grown together forming a tube. The tube is greenish at the base and violescent toward the calyx teeth. The calyx tube continues in 5 coloured sparsely haired calyx teeth (Figs 20, 21). They overlap the corolla inside the buds (Fig. 22), then gradually open (Fig. 20), and at last are fully recurved (Fig. 21). The calyx tube encloses another hard or inner tube originating from the receptacle and basal part of the stamens (Figs 24, 25). The abscission of calyx "around the cup at the approximate level of the ovary base" were studied by SIMONS (1973) in detail.

## Corolla

The petals are twisted in the bud; they are light pink and gradually become white after the flower opens. The base of the petal is shortly decurrent, unbroken, and undulating. The venation of the petal is reticulate. The number of petals may be over five in the different cv. (Fig. 29).

## Stamens

The stamens originating from the receptacle are arranged spiro-cyclically. The lower part of the adherent filaments and upper one of the receptacle form a hard, inner "calyx tube" (Figs 24, 25). The two inner rows of stamens are covered by the orange-red hairs to half length of the inner calyx tube (Fig. 32). This is the nectariferous area (Childers 1973). According to Nyárády (1958) and Löschning and Passacker (1954) nectar secretion takes place in the receptacle while in the opinion of Buchanan (cf. McGregor 1976) nectar is secreted in the fleshy score of the receptacle. My investigations suggest that the receptacle and also the lower part of the stamens participate in this process (Fig. 25). The cytology, system, physiology and history of the flower nectaries were discussed in detail by Gulyás (1975).

The true or outer and inner calyx tubes stick closely together, but after the sepals have dried, this connection remains only at the base of the two calyces and as a ring just under the teeth of outer calyx.

The spirally arranged stamens lie upon one another (Figs 24, 25) but they are well separated in the margin of the inner calyx tube. Consequently, the helical arrangement of the stamens and their length differ in every "ring". The stamens deviate in different directions; consequently, they show an irregular arrangement when viewed from above. Above the nectariferous area the stamens are white, the pollen grains in the opened anthers are grey.

The average number of stamens of C-235 is 27.3 (range 40 to 25) and 23 in C-778 (range 30 to 20) (Table 2). The stamens of each of the flowers occurring acropetally on the branch or dwarf branch were counted.
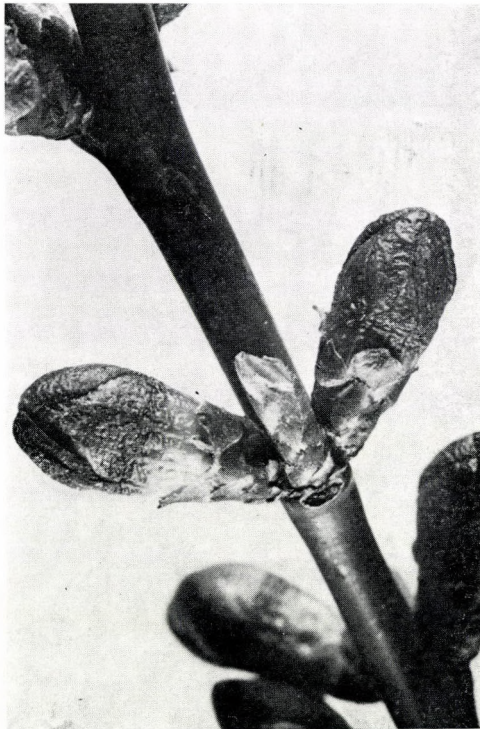
*Fig. 22.* The flowering buds originating from both sides of the vegetative one (Photo: I. Rácz)
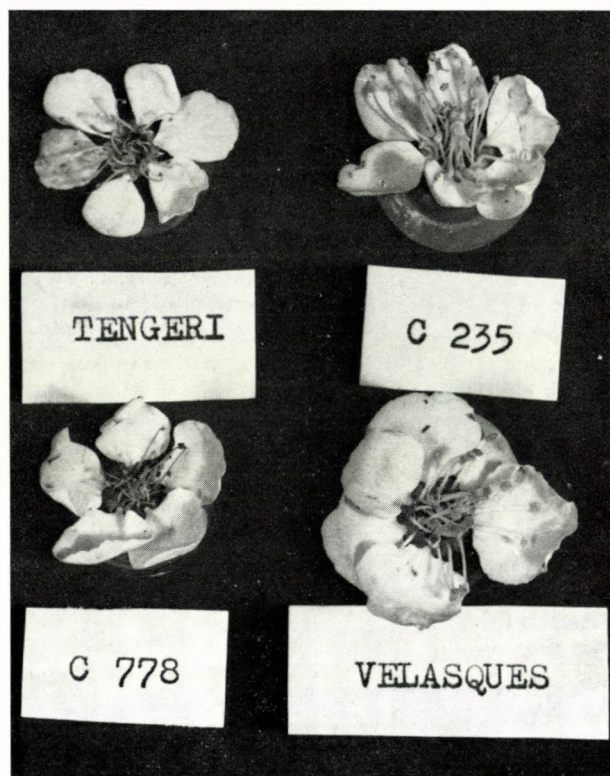
*Fig. 23.* Flowers of four cultivated varieties of *Armeniaca vulgaris* (Photo: D. KOVÁTS)

*Fig. 24.* The outer and inner hard calyx tube round the pistil (Photo: I. RÁCZ)

*Fig. 25.* Nectarproducing area in the hard calyx tube, which comprises hair and is orange-red in colour (C-235) (Photo: I. RÁCZ)
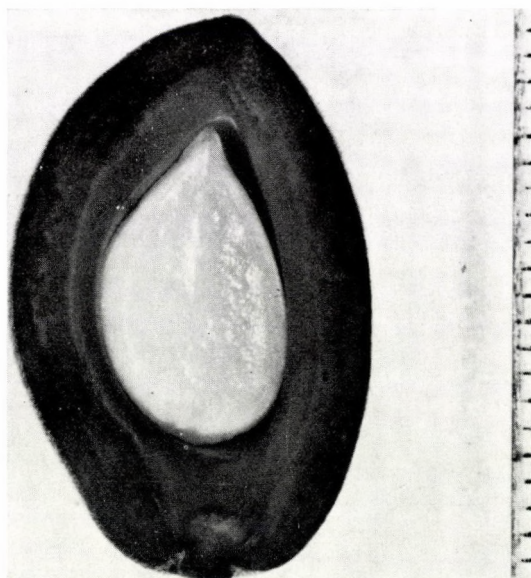
*Fig. 26.* Longitudinal section from C-778 cv. along the raphe at 15, March 1978 (Photo: I. RÁCZ)
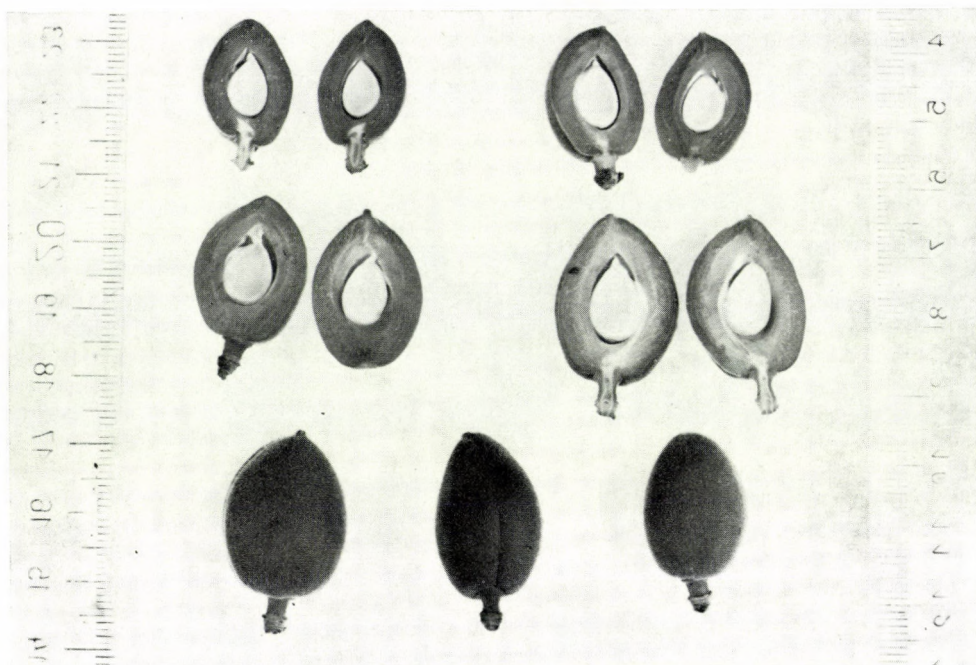
*Fig. 27.* Three different profiles of C-235 cv. in the lower row and longitudinal sections of fruits in the upper one (Photo: I. RÁCZ)
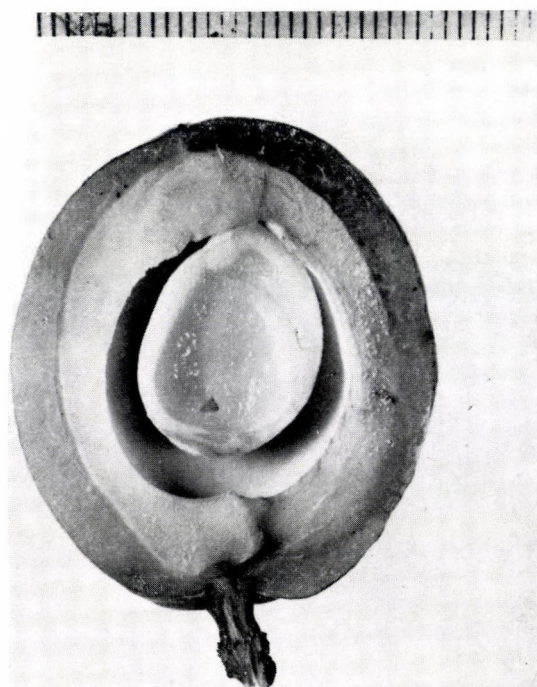
*Fig. 28.* Longitudinal sections of the C-778 fruit. The stone-fruit is still soft and white, seed contains only nutritive tissue in the fruit (Photo: I. RÁCZ)
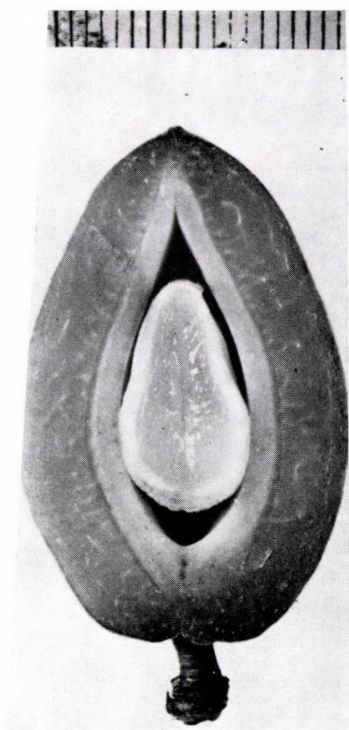
*Fig. 29.* Perpendicular section to the raphe from the fruit. The seed-coat thick and white (Photo: I. RÁCZ)
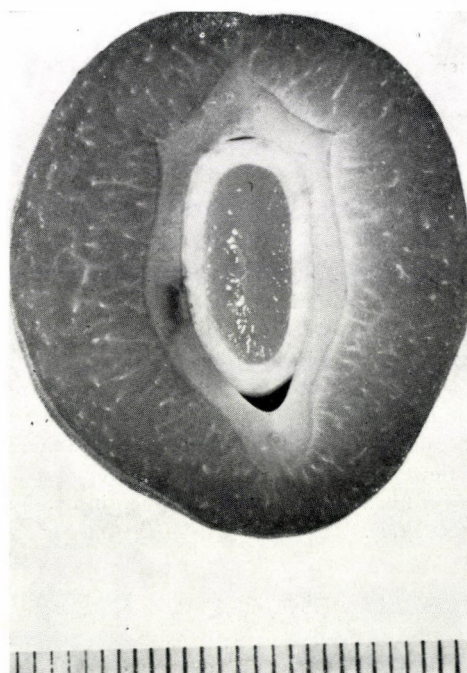
*Fig. 30.* Cross-section of a green fruit from C-235 cv. The grooves are well developed in the soft stone-fruit (Photo: I. RÁCZ)
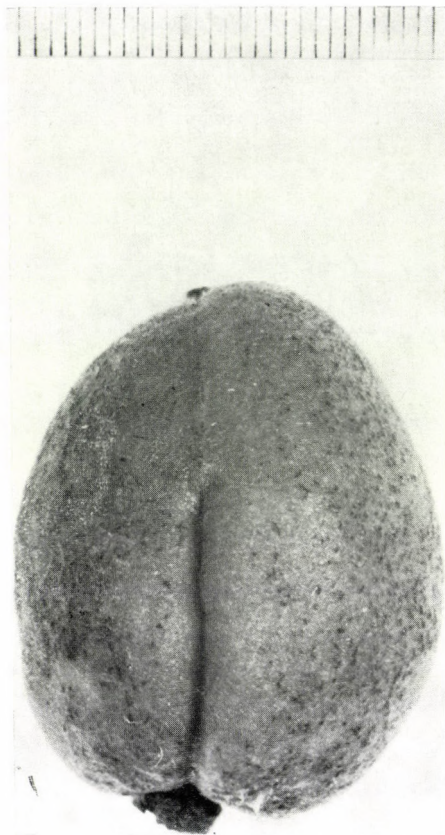
*Fig. 31.* The raphe is deeper at the base of the fruit and shallow at the style-point (Photo: I. RÁCZ)

## Pistil

The bottle-shaped pistil is perigynous (Figs 24, 25), the surface is densely hairy. Depending on the developmental phase, the length of the ovary is 3–7 mm in C-235 and 4–7 in C-778, and 1.5 mm wide at blossoming time. The styles are 12–14 mm long (Table 2).

The ovary of *Armeniaca vulgaris* is one loculated (Fig. 25). The two ovules are pedunculous, anatropous in the ovary. According to McGREGOR (1976) one of the two ovules is usually, but not always, destroyed (Figs 29, 30) after fertilization.

Many of the authors (cf. McGREGOR 1976) established differences between the length of stamens and styles, in different species of *Prunus.**

Since the stamens adhere helically in several "rings", the length of the stamens is also different in the same flower. The style and stigma develop for a long time while the length of this organ increases (Figs 21, 25). The style abscission in cv. *Wilson Delicious* happened only in stage X. (cf. SIMONS 1973).

* KOSTINA (1936), McGREGOR (1976) and others often used the *Prunus* genera name instead of *Armeniaca.*

**Table 2**

*Inflorescence, flowers*

| Serial No. | Shoot | Length of calyx | | Petal | | Number of stamens | Length of | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | tube | teeth | length | width | | pistil | ovary | |
| | C-235 | | | | | | | | |
| 1. | three-years-old branch | 8 | 7 | 13 | 11 | 25 | 18+ | 4 | Stigma and stamens are equally long |
| | | | 7 | 13 | 11 | | | | |
| | | | 8 | 14 | 3 | | | | |
| | | | 7 | 13 | 11 | | | | |
| | | | 7 | 13 | 11 | | | | |
| 2. | on the top of dwarf twig | 7 | 6 | 13 | 11 | 40 | 21 | 5 | Two pistils are in one flower, stigma longer than the outer stamens |
| | | | 5 | 12 | 12 | | 20 | 4 | |
| | | | 5 | 11 | 8 | | | | |
| | | | 7 | 13 | 13 | | | | |
| | | | 6 | 12 | 8 | | | | |
| | | | 7 | 13 | 12 | | | | |
| | | | 6 | 11 | 11 | | | | |
| 3. | on the top of dwarf twig | 7 | 6 | 13 | 9 | 28 | 17+ | 3 | Stigma and stamens are equally long |
| | | | 7 | 12 | 10 | | | | |
| | | | 7 | 10 | 9 | | | | |
| | | | 7 | 11 | 9 | | | | |
| | | | 6 | 12 | 10 | | | | |
| | | | 6 | 12 | 11 | | | | |
| 4. | on the top of dwarf twig | 7 | 7 | 12 | 12 | 26 | 20 | 5 | |
| | | | 6 | 14 | 12 | | | | |
| | | | 6 | 10 | 8 | | | | |
| | | | 6 | 14 | 14 | | | | |
| | | | 6 | 14 | 12 | | | | |
| 5. | on the top of dwarf twig | 6 | 7 | 14 | 12 | 30 | 19 | 4 | |
| | | | 6 | 10 | 10 | | | | |
| | | | 6 | 9 | 8 | | | | |
| | | | 7 | 11 | 10 | | | | |
| | | | 6 | 11 | 10 | | | | |
| | | | 6 | 12 | 11 | | | | |
| 6. | apical branch | 8 | 7 | 11 | 11 | 30 | 21 | 5 | |
| | | | 6 | 11 | 11 | | | | |
| | | | 5 | 12 | 12 | | | | |
| | | | 5 | 11 | 11 | | | | |
| | | | 5 | 11 | 11 | | | | |
| 7. | apical branch | 7 | 5 | 13 | 12 | 30 | 26 | 6 | |
| | | | 5 | 13 | 12 | | | | |
| | | | 7 | 14 | 13 | | | | |
| | | | 5 | 13 | 12 | | | | |
| | | | 5 | 13 | 12 | | | | |
| 8. | apical branch | 7 | 6 | 13 | 12 | 30 | 23 | 5 | |
| | | | 6 | 11 | 12 | | | | |
| | | | 6 | 13 | 12 | | | | |
| | | | 6 | 13 | 12 | | | | |
| | | | 6 | 12 | 12 | | | | |
| 9. | apical branch | 7 | 6 | 14 | 13 | 30 | 23 | 7 | |
| | | | 6 | 14 | 13 | | | | |
| | | | 6 | 14 | 13 | | | | |
| | | | 6 | 14 | 13 | | | | |
| | | | 6 | 14 | 13 | | | | |

| Serial No. | Shoot | Length of calyx | | Petal | | Number of stamens | Length of | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | tube | teeth | length | width | | pistil | ovary | |
| 10. | topmost flower on the apical branch | 8 | 7 | 13 | 12 | 30 | 20 | 4 | Three pistils are in one flower |
| | | | 6 | 14 | 13 | | 21 | 5 | |
| | | | 6 | 13 | 12 | | 16 | 3 | |
| | | | 6 | 13 | 12 | | | | |
| | | | 6 | 12 | 10 | | | | |
| | | | 6 | 12 | 10 | | | | |
| | | | 6 | 12 | 12 | | | | |
| | C-778 | | | | | | | | |
| 1. | two- or three-years-old branch | 7 | 5 | 12 | 11 | 25 | 20 | 5 | |
| | | | 7 | 12 | 13 | | | | |
| | | | 6 | 12 | 14 | | | | |
| | | | 5 | 12 | 13 | | | | |
| | | | 5 | 12 | 11 | | | | |
| 2. | two- or three-years-old branch | 9 | 5 | 11 | 12 | 30 | 20 | 5 | |
| | | | 6 | 12 | 12 | | | | |
| | | | 7 | 12 | 13 | | | | |
| | | | 6 | 12 | 12 | | | | |
| | | | 6 | 11 | 12 | | | | |
| 3. | two- or three-years-old twigs | 7 | 6 | 11 | 12 | 20 | 20 | 6 | |
| | | | 6 | 11 | 12 | | | | |
| | | | 7 | 12 | 13 | | | | |
| | | | 6 | 11 | 12 | | | | |
| | | | 6 | 11 | 12 | | | | |
| 4. | two- or three-years-old twigs | 7 | 6 | 10 | 12 | 20 | 21 | 7 | |
| | | | 6 | 10 | 12 | | | | |
| | | | 7 | 11 | 12 | | | | |
| | | | 6 | 10 | 12 | | | | |
| | | | 6 | 10 | 12 | | | | |
| . | topmost flower on apical branch | 7 | 5 | 10 | 12 | 20 | 19 | 4 | |
| | | | 5 | 10 | 12 | | | | |
| | | | 6 | 10 | 11 | | | | |
| | | | 5 | 10 | 12 | | | | |
| | | | 5 | 10 | 12 | | | | |

+ The flowers were measured from the base to the top of the branch

In the C-235 and C-778 convarieties of apricot, the style grows out of all of the stamens and remains on the fruits for a long time. It is probable that some authors investigated the length relations between these two organs in different developmental phases. Therefore their opinion may be based on insufficient investigations.

Other authors found a relationship between the length of the style and the production of nectar. Brown (1951) e.g. considered the style of the *Prunus domestica* cv. Jefferson to be long and the production of the nectar to be low and the opposite ratio is true in the other convarieties.

From 1968 on Surányi (1970, 1971, 1973, 1977) has carried out investigations into the length of pistil and the number of the stamens in different cv. of Hungarian apricot.

*Fig. 32.* The inner surface of the stone-fruit is smooth (Photo: I. Rácz)

**Table 3**

*Average values of calyx, petals and stamens*

| Sort | Length of calyx | | Petal | Number of stamens |
|---|---|---|---|---|
| | tube | teeth | width/length | |
| C-235 | 6.12 | 5.42 | 0.89 | 27.3 |
| C-778 | 7.40 | 5.84 | 1.10 | 23.0 |

In C-235 10 flowers were investigated and in C-778 only 5.

The fully developed organs may be characterized by these average values (Table 3). All of the values are higher in C-778 than in C-235, except the number of stamens.

But the two convarieties differ significantly only in the number of stamens. The value of SD is 2.7223 (cf. Sváb 1973) in $P_{5\%}$ level, and $t = 3.2547$.

**Table 4**

*Fruit, stone-fruit,*

| Sort | | Phenophase(s) | Fruit shape index | RGR | Area of stone fruit | Area of the cavity of stone fruit | Area of embryo | Area of seed |
|---|---|---|---|---|---|---|---|---|
| Day | Month | | | | parallel with the raphe in mm² | | | |
| C-235 | | | | | | | | |
| 12 | V. | 23.<br>32.1.2 | 1.80 | — | 96.0 | 56.6 | — | — |
| 29 | V. | 23, 24<br>33.1.1.2<br>33.1.2 | 1.44 | 0.160 | 600.0 | 289.0 | 10.6 | — |
| 9 | VI. | 24.<br>33.1.2.2 | 1.20 | 0.020 | 600.0 | 307.1 | 21.9 | — |
| 23 | VI. | 24.<br>33.1.2.3 | 1.24* | —0.060 | 598.0 | 240.3 | 62.8 | — |
| 6 | VII. | 24.<br>33.2.1 | 0.69 | 0.160 | 800.0 | 339.3 | 293.7 | — |
| 25 | VII. | 24.<br>33.2.1 | 0.94 | 0.020 | 800.0 | 340.0 | 325.2 | — |
| C-778 | | | | | | | | |
| 12 | V. | 23.<br>32.1.2 | 3.00 | — | 170.0 | 94.6 | — | 75.4 |
| 29 | V. | 23. 24.<br>33.1.1.2<br>33.1.2 | 1.93 | 0.140 | 832.0 | 282.7 | 10.6 | 197.9 |
| 9 | VI. | 24.<br>33.1.2.2 | 2.25 | 0.002 | 580.0 | 235.6 | 28.3 | 186.9 |
| 23 | VI. | 24.<br>33.1.2.3 | 2.22 | 0.000 | 713.0 | 270.9 | 186.9 | 186.9 |
| 6 | VII. | 24.<br>33.2.1 | 1.75 | —0.001 | 713.0 | 270.9 | 197.9 | 197.9 |
| 25 | VII. | 24.<br>33.2.1 | 1.39 | 0.100 | 768.0 | 208.9 | 208.9 | 208.9 |

* The sample branch was taken from the north side of the tree

He found a correlation between the fertilization ability and the number of stamens/length of pistil. According to this examination, the self-fertile cv. of apricots have large pistils, in contrast to this short pistil.

## *Fleshy and stone fruit and seed*

The pedicel is not so short in C-778 as in C-235. The shape of the C-778 is strongly asymmetric and less of the C-235. The fruits are green, hirsute, the fleshy fruit (fleshy pericarp

*embryo, seed*

| Wall thickness of the flesh in mm | | | Wall thickness of the stone-fruit in mm | | | Degree of hardness of stone-fruit | State of nutritive tissue |
|---|---|---|---|---|---|---|---|
| perpendicular to raphe | along the raphe | in cross-section | perpendicular to raphe | along the raphe | in cross-section | | |
| 2 | 3 | 4 | 2 | 1 | 1 | easily may be cut by razor blade | semi-transparent |
| 4 | 7 | 7 | 4 | 2 | 2 | may be cut by razor blade | semi-transparent |
| 5 | 9 | 7 | 4 | 2 | 2 | may be cut by knife | semi-transparent seed-coat 1 mm thick |
| 5 | 7 | 8 | 5 | 2 | 2 | hardly may be cut by knife | gelatinous, seed-coat 2 mm thick, white |
| 15 | 15 | 17 | 7 | 2 | 2 | stone-hard | absent |
| 15 | 15 | 17 | | | | stone-hard | absent |
| 3 | 3 | 3 | 1 | 1 | 1 | easily may be cut by razor blade | semi-transparent |
| 2 | 5 | 6 | 4 | 2 | 2 | may cut be by razor blade | semi-transparent, water colour |
| 4 | 5.5 | 6.5 | 4 | 2 | 2 | may cut be by razor blade, groove can be seen | semi-transparent seed-coat can be seen |
| 4 | 5.5 | 6.5 | 5 | 2 | 2 | hardly may be cut by knife | absent |
| 4 | 5 | 7 | 4 | 2 | 2 | hardly may be cut by knife | absent |
| 7 | 11 | 12 | 4 | 2 | 2 | stone-hard | absent |

The fruits become yellow in both convarieties on 25, June

or mesocarp) is hard, the stone fruit (= inner layer of pericarp = endocarp) is soft and in the cavity of the "stone" fruit there is nutritive tissue (Figs 29, 30). In this developmental phase the embryo is not visible (Figs 26, 27 and Table 4).

The fleshy pericarp is rich in veins (Figs 29, 30). The embryo is visible at the end of May (Table 4). The embryo and the seed-coat around the nutritive tissue (the remaining nucellus and endosperm) are more characteristic at the beginning of June (Figs 28, 29, 30). The endocarp can be cut easily with a knife, the grooves protrude on the dorsal side of the
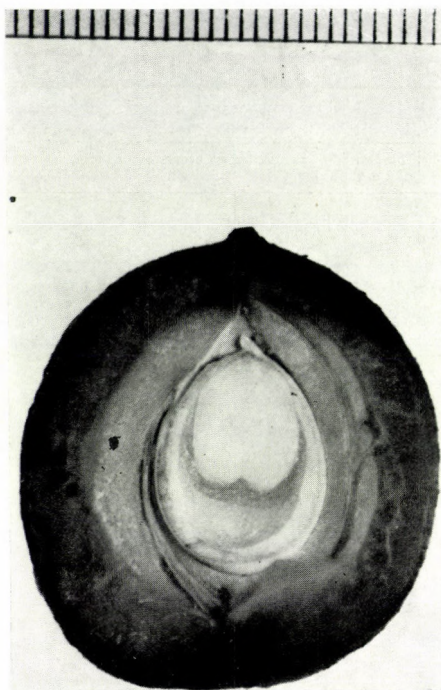
*Fig. 33.* Developing cotyledons and the remaining nutritive tissue together in the seed (Photo: I. RÁCZ)

suture (Fig. 30). The "stone" fruit remains white and soft until the embryo develops fully. The colour becomes hard after the embryo has evolved and the nutritive tissue has disappeared. KANIEWSKI (1963) studied the formation of sclereids and the lignification of cell walls in the pit (endocarp) of *Armeniaca vulgaris*. According to him "In cross-sections, on each level of the developing pit the formation of sclereids and lignification start first at the ventral suture, i.e. near the place of marging of the carpel edges . . . first appear at the seed cavity".

Wine-red patches appear in the fleshy pericarp; the base of fruit of C-235 grow on the pedicel (Fig. 31), the stone fruit can be cut with difficulty at the beginning of June. At the same time the nutritive tissue in the seed is larger than the embryo (Figs 32, 33; Table 4). The fleshy and stone fruit become ripe in July to August but the maturation time is different and characteristic for the convarieties. The ripe fruit is coloured, the stone fruit is hard and in the seed there are only the embryos full of nutrients. The asymmetry of the stone fruit (Figs 33, 34) and seed is determined by the fruit and conversely.

## *Mature fruit*

### "C-235, Magyar kajszi"

The colour of the mature fruit is orange-yellow on one side and wine-red on the other. The surface is velvet, hirsute, the skin is thin and aromatic and its taste is pleasant like that of the fleshy fruit. The shape of the fruit is wide ovate, the width, and length values are near
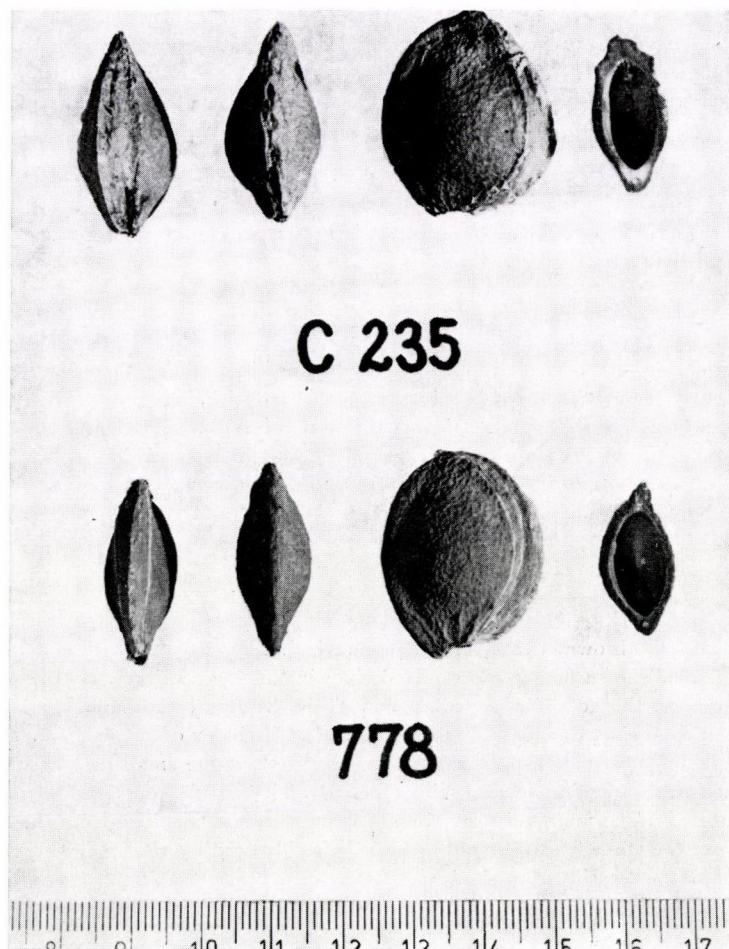
*Fig. 34.* Stone-fruit of cv. C-235 and C-778 of *Armeniaca vulgaris* (Photo: I. Rácz)

to each other in the mature fruit. The hollow in the fruit base is 4 mm. The groove of the fruit and the style-point go farther over the median axle. The style-point arises from the surface (Fig. 31). The depth of the raphe is 2–3 mm at the base of the fruit and 0.5–1 mm beside the style-point (Fig. 31). The pedicel is deep in the mature fruit, consequently the fruit is almost sessile.

## Stone fruit

The stone fruit is light brown, its surface is pitted, wide ovate and asymmetric in shape, and humpy in the middle. The peduncle is hollow, 1–1.5 mm at the base, which is asymmetric. The style-point is on the left side of the median axle; the apex is acuminate (Fig. 34). The shape index of the mature stone fruit is 5. The ventral suture is sharp, the dorsal suture is obtuse and bearing several deep and shallow holes for the articulation of the veins (Fig. 34). On the pitched ventral suture there is a protuberant sharp groove on each side.

Sometimes there is an accessory groove between the ventral suture and the main groove (Fig. 34). A large vein runs between the ventral suture and groove(s) from the pedicel to the apex of the stone fruit.

The mature stone fruit can be separated easily from the fleshy fruit. The inner surface of the stone fruit is smooth, the seed filling up the hole.

## Seed

Wide ovate in shape, flat, the seed-coat is brown and long-wise wrinkled, the apex is acuminate, and the taste is sweet.

## "C-778 Rózsabarack"

The aromatic mature fruit is pale-yellow on one side, and reddish on the other. The surface is slightly hirsute, the skin is thin, the taste is sourish. The pulpy, fleshy fruit has a pleasant taste. The fruit is asymmetrical, ovate-lanceolate, elongated and flat. The width and length values are higher than the thickness. The hole in the fruit base is over 4 mm, but the base is also shorter than in C-235. The groove of the fruit and style-point go far over the median axle like in C-235. The depth of the raphe is 1.5 mm at the base and 0.2 mm at the apex of fruit.

## Stone fruit

They are pale brown, ovate, and asymmetrical. The two sides are convex (Fig. 34), contrary to C-235. The surface is more pitted than in "Magyar kajszi". It is strongly asymmetric at the base, the hole of the pedicel may reach 2 mm at the base. The style-point is shifted to the dorsal side, the apex is obtuse (Fig. 34). The index of shape is 5.3.

The ventral suture is obtuse, and double-edged; there are small hollows on both sides of the dorsal suture referring to the veins (Fig. 34). The grooves on the ventral suture are hardly protuberant. The main vein runs in a valley at a small distance from the groove. The inner surface of the stone fruit is smooth, the hole is filled out by the seed. The mature stone fruit can be separated easily from the fleshy fruit.

## Seed

Ovate in shape, the base is as strongly asymmetrical as in the stone fruit, flat, and thicker in the ventral suture than in the dorsal one (Fig. 32). The style-point rises markedly on the ventral side. The seed-coat is pale brown and longwise wrinkled (Fig. 32). The seed is bitter.

The Magyar kajszi and Rózsabarack differ considerably in fruit, stone fruit and seed. The shape index of the mature fruit of C-235 is lower than that of C-778.

In the course of growth and development of the fruit many of the characteristic features change (Table 4).

As it can be seen in Table 4, the shape index of the initial, one-month-old, fruits of both convarieties is high; the lowest values can be found during ripening, and in the too mature fruit.

Closer to the spherical form, the shape index of the mature fruit of C-235 was 0.94 in 1978, the average value was 1.12 in 1979, while the flattened C-778 was 1.35 in both years.

The relative growth rate (RGR) of C-235 increased steadily, except on 23, June. The RGR value of C-778 was higher in the one-and-a-half month-old fruit, and the further values were nearer to 0 (steady increases in absolute values). The RGR values increased considerably

in the last two weeks before maturity was reached. The two convarieties differ from each other in this character as well. The area of the stone fruit, cut tangentially along the raphe, increased for sextain during the last two weeks of May. By this time the wall of the stone fruit had reached its final thickness. After this time the RGR values did not change. Then a considerable increase of C-235 occurred from the end of June until the middle of July, while the C-778 changed only slightly during the same time.

The hole of the stone fruit of C-235 increased threefold in the first two weeks; later it changed steadily. C-778 reached the full developmental size between the middle and end of May.

The embryo of C-235 developed steadily and reached the maximum size at the end of June, contrary to the C-235.

The thickness of the fleshy fruit wall of C-235 showed maximum value at the beginning of June, the same value of C-778 was found only at the end of June.

The cubic content of the mature fruit of C-235 is 38 cm$^3$ by counting and 47 cm$^3$ by measuring. Consequently, $k = 1.24$. The cubage of C-778 is 21 cm$^3$ by count and 23 cm$^3$ by measurement; $k = 1.10$. These $k$ values are probably characteristic for both convarieties.

## Summary

The two convarieties differ from each other in six qualitative characters (distance between the cotyledons and epicotyl, seed plants, bud-shoot connection, length of the pedicel, grooves on the stone fruit, taste of seed) and five quantative ones (angle of divergence between the bud and branch, number of stamens, shape index of fruit and stone fruit, cubic content of fruit). But, the radicula, cotyledons, shape and form of the canopy, architecture of root and branch systems, the petioles, characters of leaves, grouping of flower buds, the double calyx tubes and nectariferous area, petals and pistils are similar in both convarieties.

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# ANATOMIA DE LA MADERA DE MYRICACEAE EN CUBA: CONSIDERACIONES ECOLOGICAS

M. A. Vales,[1] A. Borhidi[2] y E. Del-Risco[1]

[1] INSTITUTO DE BOTÁNICA DE LA ACADEMIA DE CIENCIAS DE CUBA, LA HABANA
[2] INSTITUTO DE BOTÁNICA DE LA ACADEMIA DE CIENCIAS DE HUNGRÍA, VÁCRÁTÓT, HUNGRÍA

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The morphology, anatomy of the secondary xylem, habitat, and some ecological features of the *Myricaceae* in Cuba: *Myrica cacuminis* Britt. & Wils.; *Myrica punctata* Griseb., *Myrica shaferi* Urb. & Britt., and *Myrica cerifera* L. are described. According to the values of the numerical index called "vulnerability" and "mesomorphy", it was shown the range of the ecological features of the woods of this species. From these index, we conclude the best adaptation of *M. shaferi* and *M. cerifera* to the water stress.

## Introduccion

La familia Myricaceae consta de dos géneros, de los cuales sólo *Myrica* L. está representado en Cuba. Este género posee mas de 35 especies, y según Radford et al. (1974) presenta una distribución subcosmopolita por estar ausente en el Asia austral. De este número de especies solamente 4 viven en Cuba: *Myrica cacuminis* Britt. et Wils., *Myrica punctata* Griseb., *Myrica shaferi* Urb. et Britt., endémicas y *Myrica cerifera* L. con una amplia distribución en el archipiélago cubano, las Antillas y sureste de los Estados Unidos de América.

La madera de Myricaceae parece ser muy interesante, teniendo como referencia el alto grado de primitivismo que presenta, y en consecuencia no constituye una exceptión de la regla: que los grupos con xilema primitivo tienden a existir en situaciones climáticas donde tengan garantizado el abastecimiento de agua.

## Materiales y métodos

Para el presente estudio se colectaron troncos de madera adulta de las cuatro especies de *Myrica* (Tabla 1).

**Tabla 1**

*Lista y datos de los ejemplares estudiados*

| Especies | Número de colección | Localización de los ejemplares de Herbario | Localidad de colecta |
|---|---|---|---|
| *Myrica cacuminis* | Vales 228 | HAC | Estribaciones del Pico Martí. S. Maestra. Altura: 1400 m |
| *Myrica punctata* | Vales 215 | HAC | Estribaciones del Pico Martí. S. Maestra. Altura: 800–1000 m |
| *Myrica shaferi* | Vales 310 | HAC | Loma Saca la Lengua. Sierra del Cristal |
| *Myrica cerifera* | Vales 333 | HAC | Cuabal entre Las Terrazas y Soroa. Pinar del Río |

Se elaboraron pequeñas probetas de 1×1×2 cm, las cuales fueron ablandadas en agua para su seccionamiento. Cortes transversales, longitudinales-tangenciales y longitudinales-radiales de 20–30 $\mu$m de grosor fueron obtenidos con la ayuda de un micrótomo de deslizamiento. Los cortes fueron deshidratados, aclarados, y montados en portaobjetos con bálsamoddel Canadá, según las técnicas usuales, para el estudio microscópico.

El estudio del largo de los elementos fibrosos se realizó en material macerado con ácido acético y peróxido de hidrógeno en relación 1 : 1. Para el largo de las fibras se realizaron 100 mediciones, mientras que para el resto de los caracteres se realizaron sólo 50, tanto en material macerado como en las secciones finas.

La terminología utilizada en las descripciones anatómicas de las especies, es la aceptada por la Asociación Internacional de Anatomistas de la Madera, en versión traducida al español (COROTHIE 1963).

## Caracteres generales

### *Myrica cacuminis* Britt. y Wils.

Arbusto de 2–3 m de alto, ramitas densamente pelosas, recurvas, hojas pubescentes, elipticas a orbiculares, coriáceas, enteras o con pocos dientes; de 7–18 mm de largo y 6–10 mm de ancho con glándulas resinosas, peciolo corto. Flores en amentos. Fruto en drupa pequeña.

Esta especie es endémica de la parte central de la Sierra Maestra, en los grupos de cumbres del Pico Turquino y del Pico Bayamesa, entre 1400–2000 msm. Vive principalmente en los matorrales micrófilos del piso subalpino, sobre rocas de granito y granodiorita, como especie dominante de la asociación *Ilici-turquinensi-Myricetum cacuminis* donde crece junto a *Ilex turquinensis*, *Ilex nunezii*, *Ilex nannophylla*, *Lyonia calycosa*, *Lobelia cacuminis*, *Micromeria bucheri*, *Salvia speirematoides* etc. Mas raramente se encuentra en las rocas aisladas de los pisos del monte nublado y de las pluvisilvas montanas, y forman cayos de matorrales en las crestas de las lomas de areniscas pobladas por Pinus maestrensis.

El ejemplar investigado se colectó sobre areniscas, asociado con *Rubus turquinensis*, *Vaccinium leonis*, *Vernonia praestans*, *Eupatorium paucibracteatum*, *Viburnum villosum*, *Ocotea ekmanii*, *Ternstroemia monticola* etc. endémicas de la Sierra Maestra.

### *Myrica punctata* Griseb.

Arbolito de 3–5 m de alto, hojas enteras, oblongo-oblanceoladas, de 3–5 cm de largo y 6–12 mm de ancho, con glándulas resinosas, peciolo de 1.5–3 mm. Nervios laterales prominentes. Flores en amentos. Fruto en drupa.

Es una especie endémica de las montañas orientales y centrales de Cuba, y aparentemente se divide en dos ecótipos. Uno de ellos vive en los macizos de serpentinitas, y el otro en la Sierra Maestra y la Sierra del Escambray. El ejemplar estudiado pertenece a este último, y fue colectado en los pinares montanos asociado a *Pinus maestrensis*, *Cyathea arborea*, *Clethra cubensis*, *Myrsine coriacea*, *Ilex macfadyenii*, *Gesneria viridiflora*, *Callicarpa ferruginea*, *Viburnum villosum*, etc. (Asociación *Clethro-Pinetum maestrensis*.)

### *Myrica shaferi* Urb. et Britt.

Arbusto de 2–3 m de alto, hojas oblongas, agrupadas en los extremos de las ramas, de 1.5–2.5 cm de largo y 3–5 mm de ancho, dientes pocos, algunas glándulas resinosas, margen revoluto. Flores en amento. Fruto en drupa pequeña.

Esta especia es endémica de la región nororiental de Cuba, y forma parte del estrato arbustivo de los matorrales siempreverdes subhúmedos de las montañas de serpentinitas, mas comunmente en las Sierras del Cristal y de Moa, sobre suelos jóvenes, pedregosos derivados de esta roca ignea. El ejemplar estudiado se colectó en este tipo de vegetación junto a *Pera polylepis, Manilkara mayarensis, Tabebuia simplicifolia, Ilex hypaneura, Maytenus loeseneri, Alvaradoa arborescens, Jacaranda arborea, Adenoa cubensis, Guapira ophiticola, Rheedia ruscifolia, Ariadne shaferi* y *Schmidtottia cubensis.*

## *Myrica cerifera* L.

Arbolito de 4–6 m de alto, hojas oblongas a oblanceoladas de 2–8 cm de largo, algunas dentadas, glánculas numerosas y prominentes, peciolo de 3–10 mm. Flores en amentos. Frutos en drupas pequeñas blanco cerosas.

Esta especie tiene una gran amplitud ecológica pudiendo encontrarse en: seudosabanas de origen antrópico formadas por palmas, árboles, arbustos y plantas herbáceas; lugares pantanosos o cenagosos sobre turba o arenas blancas húmedas o inundadas. En éstas se asocia a *Acoelorraphe wrightii, Sabal parviflora, Chrysobalanus icaco* y *Cladium jamaicense* entre otros.

También vive asociada a los pinares del occidente de Cuba, sobre suelos ácidos, secos y pobres en nutrientes: arenosos cuarzosos y de formación San Cayetano; como en suelos ácidos, húmedos y con niveles mas altos de nutrientes. En esta formación se asocia con *Pinus caribaea, Byrsonima crassifolia, Andropogon gracilis, A. virginicus, Aristida refracta,* y a veces con *Pinus tropicalis.* El ejemplar investigado se colectó en un matorral espinoso seco de serpentina (cuabal), que se caracteriza por un estrato arbustivo muy denso formado por arbustos micrófilos con abundancia de especies espinosas y por arbolitos aislados emergentes. En esta vegetación se asocia a *Phyllomelia coronata, Tabebuia lepidota, Brya ebenus, Annona bullata, Pseudocarpidium ilicifolium, Psidium rotundatum, Erythroxylum minutifolium, Malpighia horrida, Phyllanthus orbicularis, Neobracea valenzuelana,* y *Oplonia nannophylla* entre otras.

## Descripciones anatómicas

### *Myrica cacuminis*

Anillos de crecimiento ausentes. Poros solitarios redondos a ovales (Fig. 1). Elementos de los vasos muy pequeños a moderadamente pequeños, diámetro tangencial 26–57–86 μm, diámetro radial 39–81–112 μm. Placas de perforación simples y escalariformes, con tendencia a la formación de placas de perforación simples. En las escalariformes hasta 15 barras por placa terminal. Punteaduras areoladas opuestas y escalariformes con poro en forma de fisura. Grosor de la pared de los elementos de los vasos 1.6–4.0 μm. Talla mediana, largo total 496–653–800 μm.

Parénquima axial de tipo apotraqueal difuso, con contenidos carmelita-oscuro. Diámetro medio de las células en sección transversal 17.5 μm. Las series formadas por 2–8 células de alto ó 176–530–832 μm. Grosor de la pared 1.6 μm. Cristales de oxalato de calcio presentes en células cristalíferas septadas.

Fibrotraqueidas poligonales, cortas a muy cortas, y distribuídas radialmente. Diámetro medio en sección transversal 16.5 μm. Grosor de la pared 4–8 μm y 656–974–1312 μm de largo. Poros de las punteaduras en forma de fisura.

Parénquima radial heterogéneo; constituído por radios uniseriados y radios 3–4 seriados (Fig. 2). Los uniseriados con 1–14 células de alto ó 144–251–560 μm, y 12–17–24 μm de ancho, formados por células erectas y cuadradas con altura de 36–56–80 μm y largo radial de 16–26–
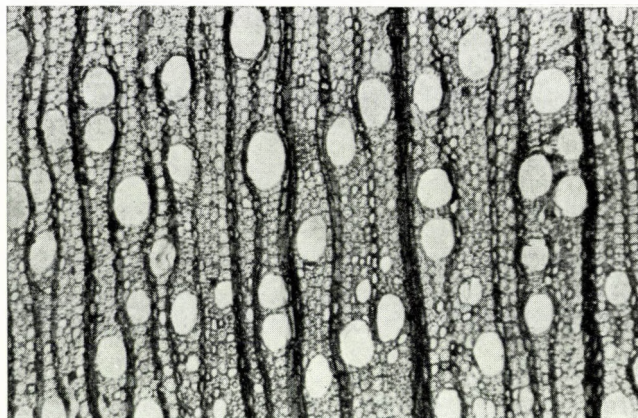
*Fig. 1.* Sección transversal de *M. cacuminis* 63×
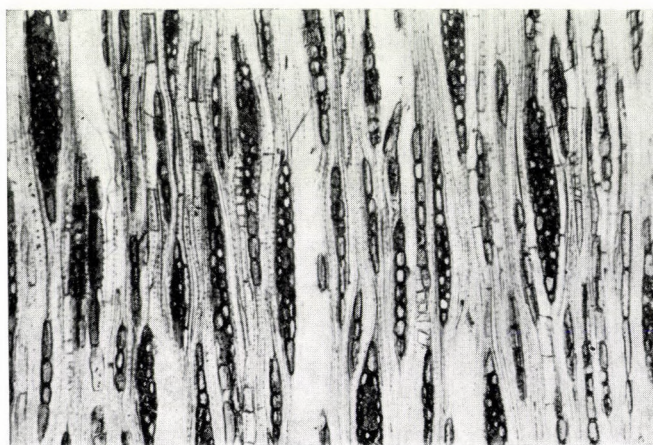
*Fig. 2.* Sección tangencial de *M. cacuminis* 63×
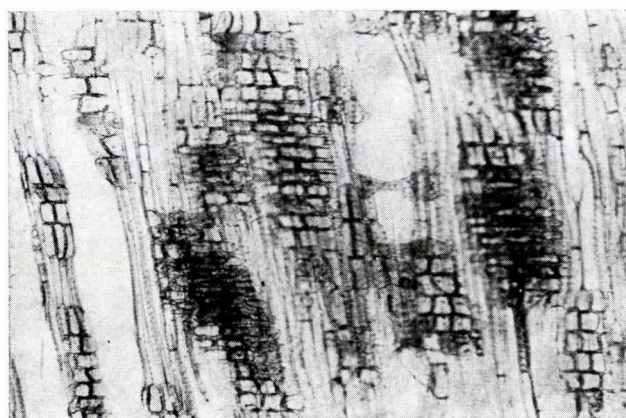
*Fig. 3.* Sección radial de *M. cacuminis* 63×

40 μm. Los tri y tetraseriados con ancho tangencial de 20–35–48 μm y altura de 12–43 células ó 120–257–512 μm, compuestos por células procumbentes con dimensiones de altura de 12–22–40 μm, ancho de 8–15–20 μm y llargo radial de 36–52–100 μm (Fig. 3); y de filas terminales de células erectas y cuadradas de iguales dimensiones a las de los uniseriados.

## *Myrica punctata*

Anillos de crecimiento ausentes, poros solitarios, redondos a ovales (Fig. 4). Elementos de los vasos muy pequeños a moderadamente pequeños. Diámetro de los vasos (tangencial) 36–52–72 μm, diámetro radial 55–76–103 μm. Placas de perforación simples y escalariformes, hasta 15 barras por placa terminal. Punteaduras areoladas opuestas y escalariformes con poro en forma de fisura. Grosor de la pared de los elementos de los vasos 2.3–5 μm. Moderadamente cortos a moderadamente largos 336–690–1024 μm.

Parénquima axial de tipo apotraqueal difuso, con contenidos de color carmelita oscuro. Diámetro medio de las células en sección transversal 15.5 μm. Las series del parénquima axial compuestas por 2–8 células de alto ó 240–558–864 μm. Grosor de la pared 1.0–1.6 μm. Cristales poliédricos de oxalato de calcio en células cristalíferas septadas, observándose 1–2 cristales en cada cámara.

Fibrotraqueidas poligonales, muy cortas a cortas, y distribuídas radialmente. Diámetro medio en sección transversal 18 μm, y 816–1148–1472 μm de largo. Punteaduras areoladas redondas con poros en forma de fisura.

Parénquima radial heterogéneo, formado por radios uniseriados y radios 3–4seriados (Fig. 5). Los uniseriados con 1–14 células de alto ó 96–301–768 μm y 10–16–21 μm de ancho, compuestos por células erectas y cuadradas con altura de 22–52–73 μm y largo radial de 21–27–41 μm. Los tri y tetraseriados con ancho tangencial de 21–39–63 μm y altura de 10–29 células ó 208–418–760 μm, formados por células procumbentes con dimensiones de altura de 12–22–33 μm, ancho de 10–17–27 μm y largo radial de 41–63–105 μm (Fig. 6); y por filas terminales de células erectas y cuadradas con iguales dimensiones a las de los uniseriados.

## *Myrica shaferi*

Zonas de crecimiento presentes, limitadas por una línea de 3–4 fibras de paredes engrosadas y aplanadas radialmente. Poros solitarios, redondos a ligeramente ovales (Fig. 7). Elementos de los vasos muy a moderadamente pequeños. Diámetro tangencial 28–41–64 μm, diámetro radial 28–50–80 μm. Placas de perforación simples y escalariformes, hasta 15 barras por placa terminal. Se observa un debilitamiento en la formación de placas de perforación simples. Punteaduras areoladas opuestas y escalariformes, con poro en forma de fisura. Grosor de la pared de los elementos de los vasos 1.6–3.3 μm. Elementos de los vasos medianos a moderadamente largos, largo total 528–874–1216 μm.

Parénquima axial muy escaso, de tipo apotraqueal difuso. Diámetro medio de las células en sección transversal 14 μm, las células con contenidos de color carmelita oscuro. Series del parénquima axial compuestas por 2–7 células de altura, largo de las series 383–697–944 μm. Grosor de la pared 1.6 μm. Muy frecuentemente se observa la presencia de cristales de oxalato de calcio en las células cristalíferas septadas del parénquima.

Fibrotraqueidas poligonales, cortas y con distribución radial. Diámetro medio en sección transversal 15 μm. Grosor de la pared 3.0–6.0 μm y 864–1255–1600 μm de largo. Punteaduras areoladas con poro en forma de fisura.

Parénquima radial heterogéneo, compuesto radios uni y biseriados (Fig. 8). Los uniseriados con 1–14 células de alto ó 176–392–936 μm y 8–14–20 μm de ancho, formados por células erectas y cuadradas con altura de 18–30–45 μm y largo radial de 11–17–26 μm. Los
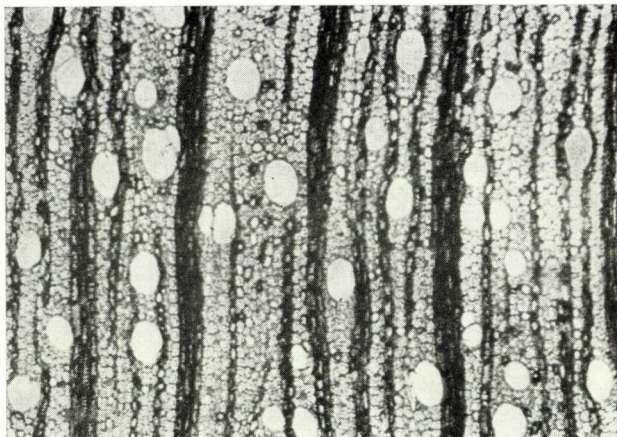
*Fig. 4.* Sección transversal de *M. punctata* 63×
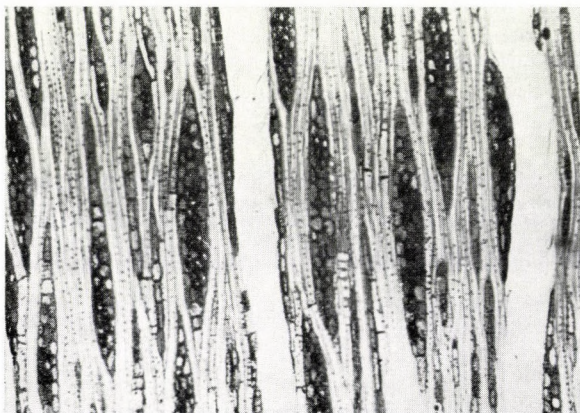
*Fig. 5.* Sección tangencial de *M. punctata* con células cristaliferas septadas 63×
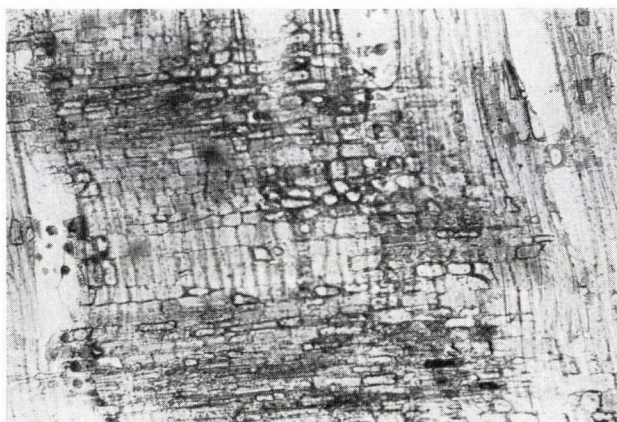
*Fig. 6.* Sección radial de *M. punctata* 63×
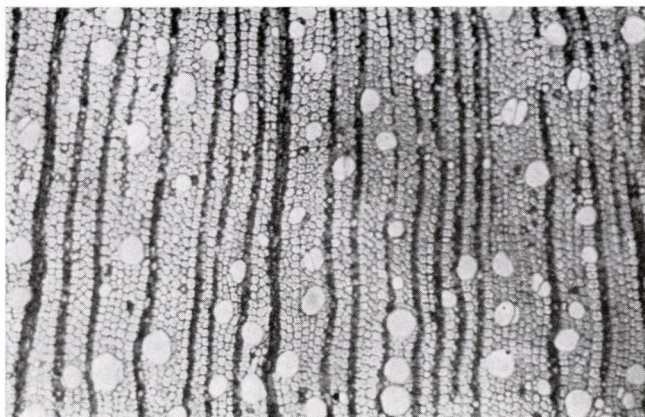
*Fig. 7.* Sección transversal de *M. shaferi* 63×
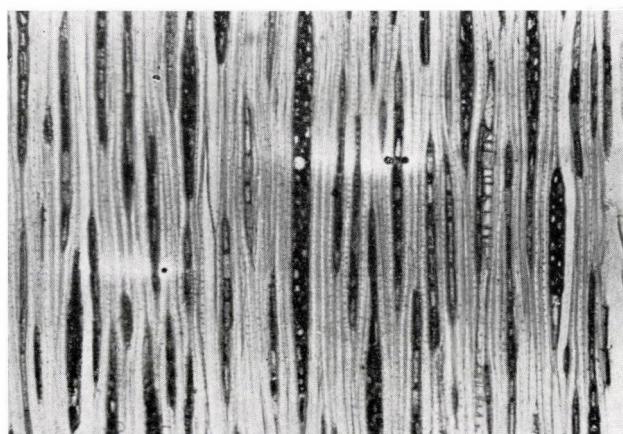
*Fig. 8.* Sección tangencial de *M. shaferi* con células cristaliferas septadas 63×
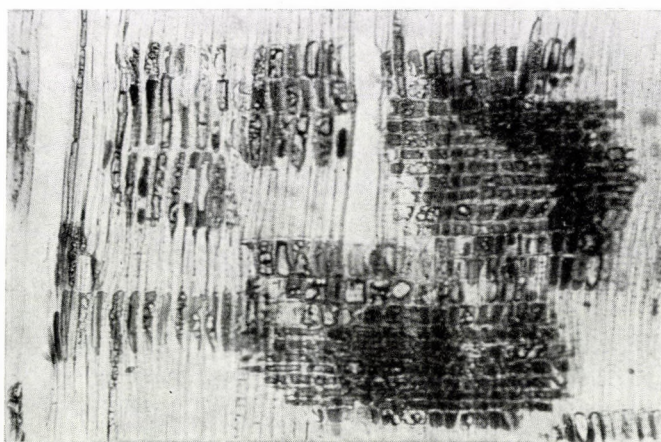
*Fig. 9.* Sección radial de *M. shaferi* 63×

radios biseriados con ancho de 20–26–32 μm y altura de 11–24 células ó 304–496–800 μm, formados por células procumbentes con altura de 19–24–35 μm, ancho de 8–13–19 μm, y largo radial de 34–46–61 μm (Fig. 9); y en los extremos por filas de células erectas y cuadradas de iguales dimensiones a las de los radios uniseriados.

## *Myrica cerifera*

Zonas de crecimiento presentes, limitadas por una línea de hasta 5 fibras aplanadas radialmente y con paredes engrosadas. Poros mayormente solitarios aunque con frecuencia se observan múltiples radiales de 2–3 elementos (Fig. 10). Elementos de los vasos muy pequeños. Diámetro tangencial 24–39–48 μm, diámetro radial 32–55–64 μm. Placas de perforación simples y escalariformes de hasta 14 barras por placa. Se observa una marcada tendencia a la formación de placas de perforación simples. Punteaduras areoladas opuestas y escalariformes con poros en forma de fisura. Grosor de la pared de los elementos de los vasos 1.6–3.2 μm. Medianos a moderadamente largos, largo total 512–705–1008 μm.

Parénquima axial de tipo apotraqueal difuso, ocasionalmente en contacto con los poros y otras formando líneas tangenciales de hasta 6 células. Se observan contenidos de color carmelita oscuro en las células. Diámetro medio en sección transversal 16 μm. Las series del parénquima compuestas por 3–8 células de alto ó 432–627–832 μm. Grosor de la pared 1.6 μm. Muy frecuentemente se observan cristales poiédricos de oxalato de calcio en células cristalíferas septadas.

Fibrotraqueidas poligonales muy cortas a cortas, y con distribución radial. Diámetro medio en sección transversal 15 μm. Grosor de la pared 3–6 μm y 816–1218–1536 μm de largo. Punteaduras areoladas redondas con poros en forma de fisura. Parénquima radial heterogéneo, compuesto por radios uni y biseriados (Fig. 11). Los uniseriados con 1–16 células de alto ó 72–305–456 μm y 8–12–16 μm de ancho; formados por células erectas y cuadradas con altura de 40–73–144 μm y largo radial de 12–29–40 μm. Los radios biseriados con ancho de 20–24–28 μm y altura de 10–31 células ó 288–472–768 μm y formados por: células procumbentes con dimensiones de altura de 16–23–32 μm, ancho de 8–14–20 μm y largo radial de 40–61–80 μm (Fig. 12), las cuales ocupan la mayor parte del radio; y extremos de filas de células erectas y cuadradas con las mismas dimensiones que las de los uniseriados. Células envolventes frecuentes.
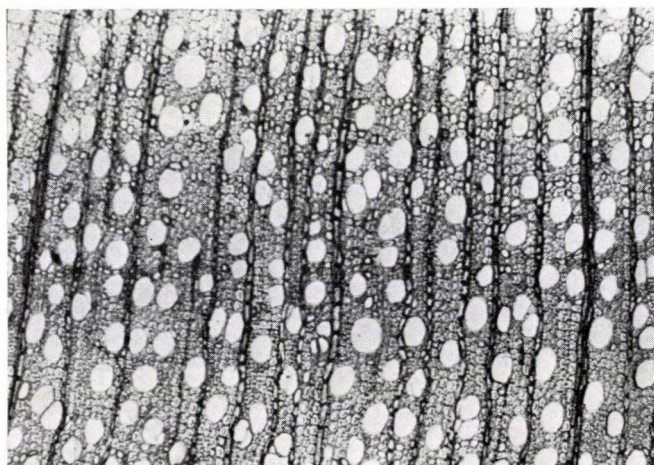
*Fig. 10.* Sección transversal de *M. cerifera* 63×

*Fig. 11.* Sección tangencial de *M. cerifera* 63×

*Fig. 12.* Sección radial de *M. cerifera* 63×

## Análisis tisular

Las especies del género *Myrica* aquí estudiadas presentan porosidad difusa, con poros mayormente solitarios y muy numerosos, y de formas redondos a ovales. Los elementos de los vasos son muy a moderadamente pequeños y medianos a moderadamente largos, con placas de perforación de tipo escalariforme, presentando hasta 15 barras por perforación. En las cuatro especies se observa la tendencia a la formación de placas de perforación simples, tendencia ésta que se mostró mas marcada en *Myrica cerifera* y *M. cacuminis*. Las barras de las placas de perforación muestran ocasionalmente algunas modificaciones: en primer lugar las barras furcadas, y como segunda anomalía mas común la multiperforada, en la cual 2 ó mas son atravesadas, formándose perforaciones ovales (Fig. 13).
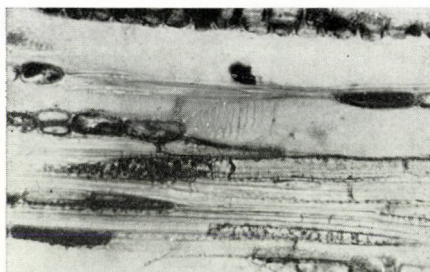
*Fig. 13.* Sección tangencial con placas de perforación escalariformes 157×

Parénquima axial predominantemente apotraqueal difuso, aunque en ocasiones se encuentran células de éste en contacto con los poros, y en otras pueden encontrarse grupos de hasta 6 células dispuestas tangencialmente. Las series del parénquima compuestas por 2–8 células rectangulares. En las 4 especies estudiadas se observan cristales poliédricos de oxalato de calcio en células cristalíferas septadas.

Existe una estrecha relación entre la altura de los radios 1–2seriados y multiseriados, y el largo de los elementos de los vasos (Tabla 2). En *M. cacuminis* y *M. punctata*, donde existen radios medulares tri y tetraseriados, éstos resultan ligeramente mas pequeños que los biseriados de *M. shaferi* y *M. cerifera*. Por otra parte se observó que las paredes tangenciales de las células de los radios medulares están engrosadas y presentan punteaduras prominentes (Fig. 14).

La presencia de elementos de los vasos muy a moderadamente pequeños, y medianos a moderadamente largos; poros solitarios y muy numerosos con placas de perforación escalariformes y punteaduras de las paredes de los vasos opuestas y escalariformes, radios medulares heterogéneos, así como el índice relativamente bajo del cociente largo de las fibras entre el largo de los elementos de los vasos, el cual varía en las especies estudiadas de 1.4–1.7, evidencian el grado de primitivismo del xilema de este grupo.

**Tabla 2**

*Valores de los principales caracteres observados*
(expresados en $\mu$m)

| Especies | Elementos de los vasos | | | | Fibras | | Parénq. axial | | Radios Medulares | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diám. tang. | Diám. rad. | Largo total | No. de Barras por placa de perforación | Diám. medio | Largo | Diám. medio | No. de células de las series | Ancho en No. de células | Altura de los uni-seriados | Altura de los multi-seriados |
| *Myrica cacuminis* | 57 | 81 | 653 | 0–14 | 15 | 974 | 17 | 2–8 | 1–4 | 251 | 258 |
| *Myrica punctata* | 53 | 76 | 691 | 0–15 | 15 | 1148 | 16 | 2–8 | 1–4 | 301 | 418 |
| *Myrica shaferi* | 41 | 50 | 874 | 0–15 | 19 | 1255 | 14 | 2–7 | 1–2 | 392 | 496 |
| *Myrica cerifera* | 40 | 55 | 705 | 0–15 | 17 | 1218 | 16 | 3–8 | 1–2 | 305 | 472 |

*Fig. 14.* Sección radial *M. cerifera* donde se observan los engrosamientos tangenciales de las células de los radios medulares 157×

Por su parte *M. cerifera* mostró la mayor tendencia a la formación de placas de perforación simples, lo que junto a su amplia distribución, parece ser indicativa de una mayor especialización e interpretada desde el punto de vista anatómico como la especie mas jóven de las cuatro estudiadas. A través de la estructura del xilema distinguimos 2 grupos, basados en el ancho de los radios medulares en número de células: un primer grupo en el que solo es posible observar radios uni y biseriados, donde se encuentran *M. cerifera* y *M. shaferi*; y un segundo grupo donde se observan radios 1–4 seriados en el que se encuentran *M. cacuminis* y *M. punctata*.

## Consideraciones ecológicas

Las zonas de crecimiento son consideradas aquí en relación directa con la ecología y mas probablemente con las características de las maderas en la conducción del agua. Las zonas de crecimiento en las especies cubanas del género *Myrica* parecen ser indicadoras de las fluctuaciones en la disponibilidad de agua. Las muestras de *M. shaferi* y *M. cerifera* presentan zonas de crecimiento perfectamente distinguibles a diferencia de las otras 2 especies donde no fueron observadas. Esta situación, interpretada de acuerdo a las características ecológicas donde fueron colectadas las muestras, evidencia que *M. shaferi* y *M. cerifera* colectadas sobre serpentina, presentan fluctuaciones en la adquisición de agua del suelo debido a la poca retención de ésta en este tipo de suelo, así como los períodos de lluvia y sequía, no obstante tener índices altos de pluviosidad; mientras que *M. cacuminis* y *M. punctata* colectadas en la zona de las pluvisilvas montanas presentan uniformidad en el contenido de agua del suelo.

Carlquist (1975a) plantéó que la producción de elementos traqueales estrechos parece brindar gran resistencia a las tensiones en las columnas de agua del xilema. Bajo este criterio un mayor número de poros por milímetro cuadrado evidencia gran resistencia al déficit de agua, en el sentido en que esta seguridad numérica garantiza que no se afecte el sistema grandemente aunque existan vasos no aptos para la conducción del agua debio al embolismo de aire. Aunque sería posible esperar que el número de poros por milímetro cuadrado resulte de una forma inversamente proporcional al diámetro de los vasos, esto varía dentro de límites extremos como fue demostrado por Carlquist y DeBuhr (1977).

El término vulnerabilidad due definido por Carlquist (1977), como la relación existente entre el diámetro de los vasos y el número de poros/mm$^2$, señalando que bajos valores de este índice sugieren características xeromórficas. De los valores de este índice obtenidos para las especies estudiadas (Tabla 3) se evidencia que *M. shaferi* y *M. cerifera*, colectadas sobre serpentina, suelo altamente permeable, presentan una mayor adaptación al déficit de agua que las otras 2 especies que viven en montañas, donde la humedad del suelo y la atmosfera son altas.

Por otra parte, Carlquist (1975b) señaló que el largo de los elementos de los vasos parece ser un índice sensible de xeromorfismo ó mesomorfismo; no obstante estar controlado de forma independiente por el largo de las células iniciales fusiformes del cambium. De esta forma podría plantearse que los elementos de los vasos largos representan un sistema conductor para las especies mesófitas, mientras que los cortos lo serían de maderas xerófitas. Por esta razón, multiplicando el índice de "vulnerabilidad" por el promedio del largo de los elementos de los vasos, se obtiene otro índice que Carlquist denominó "mesomorfía". Según se muestra en la Tabla 3, los valores de "mesomorfía" para las especies estudiadas de esta familia varían de 134–725. De esto se corrobora que *M. shaferi* y *M. cerifera*, no obstante tener índices de "vulnerabilidad" y "mesomorfía" relativamente bajos, poseen características de especies mesófitas en el xilema secundario. Esta aparente contradicción se explica teniendo en consideración que este grupo representa una familia bastante primitiva. Sus especies viven mayormente en ecótopos bien provistos

**Tabla 3**

| Especies | Poros/ mm$^2$ | Vulnera-bilidad | Meso-morfía | Lf/Lv | Prom. de Pluviosidad anual (mm) |
|---|---|---|---|---|---|
| *Myrica cacuminis* | 66 | 0.87 | 568 | 1.5 | 1400–2200 |
| *Myrica punctata* | 50 | 1.05 | 725 | 1.7 | 1400–2000 |
| *Myrica shaferi* | 108 | 0.38 | 332 | 1.4 | 1400–2000 |
| *Myrica cerifera* | 208 | 0.19 | 134 | 1.7 | 1600–2000 |

de agua, donde transpiran abundantemente a pesar de su morfología externa micrófila de una apariencia xeromorfica.

Se observa que esta tendencia filogenética para adaptarse al ambiente mas seco, solo se encuentra en el grupo de las especies de este género con radios medulares uni y biseriados. De esta forma las características fenotípicas xerífitas de estas especies deben considerarse un fenómeno de "Seudoxeromorfismo".

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# REVIEW OF THE USTILAGINALES OF HUNGARY

## WITH SPECIAL REGARD TO THE RESULTS OBTAINED AFTER 1950

K. VÁNKY,[1] J. GÖNCZÖL[2] and S. TÓTH[3]

[1] UPPSALA UNIVERSITY, INSTITUTE OF SYSTEMATIC BOTANY, UPPSALA, SWEDEN
[2] HUNGARIAN NATURAL HISTORY MUSEUM, BOTANICAL DEPARTMENT, BUDAPEST, HUNGARY
[3] UNIVERSITY FOR AGRICULTURAL SCIENCES, BOTANICAL DEPARTMENT, GÖDÖLLŐ, HUNGARY

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A check list of Hungarian Ustilaginales including generic descriptions and the host plants is presented. For the material collected after 1950 the complete data for every collection is given. These also include new Hungarian records of 37 smut species and 21 host plants. The Ustilaginales not yet found but probably present in Hungary are listed too.

## Introduction

GUSZTÁV MOESZ, (1873–1946) in his monograph (1950) dealt with the Ustilaginales found in Carpathian basin, including among others Banat, Transylvania, Upper Northern Hungary and also Sub-Carpathia. In his beautifully illustrated work MOESZ enumerated 127 species of which 85 being reported from the present territory of Hungary. However, according to our current species concept they should be treated as 70 species only. UBRIZSY (1967) enumerated the Ustilaginales from the Carpathian basin, with literature references. He uncritically used MOESZ's data and only added some of the collections made after 1950.

During the last 30–40 years many new data from Hungary have also been accumulated and the species concept within Ustilaginales has changed considerably. Nowadays the host specificity is usually not accepted as species criterium morphological characters are mainly used for species delimitation. For example, many stripe smuts of grasses with the same spore morphology are now included in *Ustilago striiformis* (Westend.) Niessl but were formerly regarded as belonging to several different species (*U. alopecurivora* Ule, *U. bromina* H. Syd., *U. salveii* Berk. et Br., etc.). This also holds true for many *Entyloma* species which form lead coloured sori on Gramineae [E. dactylidis (Pass.) Cif.], and for species of different *Ranunculus* [e.g. *E. ranunculi* (Bon.) Schröt., *E. ranunculi-scelerati* Kochm., *E. ranunculorum* Liro, etc.] with a thin, smooth spore wall (now *E. ficariae* Fisch. v. Waldh.). Many *Ustilago*, which develop in the spikelets of Gramineae, for example *Ustilago bromimollis* Liro, *U. bromivora* (Tul.) Fisch. v. Waldh., etc. are now included in *U. bullata* Berk. The smuts which form spores in the anthers of Caryophyllaceae and are morphologically identical [*Ustilago antherarum* (D. C.) Fr., *U. lychnidis-dioicae* Liro, *U. silenes-inflatae* Liro, etc.] are now treated under the name *U. violacea* (Pers. ex Pers.) Roussel. Similarly, the species of *Sorosporium* [*S. melandryi* H. Syd., *S. purpureum* (Hazsl.) Liro, *S. silenes-inflatae* (Zigno) Cif., etc.] which develop in the flowers of Caryophyllaceae, are now called *S. saponariae* Rudolphi. On the other hand, the heterogenic *Anthracoidea caricis* (Pers.) Bref. s. lato has been divided in many species according to morphological criteria. These *Anthracoidea* species parasitize one or several *Carex* species which belong to the same or closely related sections.

As a result of nomenclatorial investigations, some Ustilaginales species names has been changed. For example, the legitimate name *Ustilago neglecta* Niessl replaced the formerly used *U. panici-glauci* (Wallr.) Wint., *Urocystis floccosa* (Wallr.) Henders. replaced *U. hellebori-viridis* (D. C.) Moesz, and *Urocystis syncocca* (L. A. Kirchn.) B. Lindeb. replaced *U. hepaticae-trilobae* (D. C.) Moesz. Some names turned out to be superfluous synonyms. For example *Sphacelotheca strangulans* (Issats.) Moesz is *S. montaniensis* (Ell. et Holw.) Clint., *Urocystis polygonati* Moesz et Ulbrich is *U. polygonati* (Lavr.) Zundel, or *Sorosporium cenchri* P. Henn. var. *levis* Vörös et Ubrizsy is *S. cenchri* P. Henn.

Some species were incorrectly treated as Ustilaginales. Among these are *Entyloma schinzianum* (P. Magn.) Höhnel which is actually *Exobasidium schinzianum* P. Magn.; *Tilletia sphagni* is the conidial form of the Discomycete *Helotium schimperi* Nawaschin; *Ustilago fussii* Niessl is nothing less than the Myxomycete *Lepidoderma carestianum* (Rabenh.) Rostr. This applies to the entire genus *Graphiola* which is now placed in Fungi Imperfecti.

In a few instances the generic concept has also changed, thus the genus *Ginanniella* is now included in *Urocystis*, whereas *Anthracoidea* and *Sporisorium*, described a long time ago but then "forgotten", have recently been revived. During the last three or four decades many new genera have been described; among these *Moesziomyces* and *Orphanomyces* were found in Hungary and *Ustacystis* and *Ustilentyloma* are probably also present. As a result of systematic collecting in and scrutinies in phanerogamic herbaria, 2 genera and more than

**Table 1**

*Synoptic table of Hungarian Ustilaginales*

| Genera | Number of species | | Number of fungus/ host comb. (present) |
|---|---|---|---|
| | present | probable | |
| *Anthracoidea* | 8 | 9 | 10 |
| *Burrillia* | 0 | 1 | 0 |
| *Doassansia* | 3 | 8 | 3 |
| *Doassansiopsis* | 1 | 3 | 3 |
| *Entorrhiza* | 0 | 5 | 0 |
| *Entyloma* | 15 | 55 | 20 |
| *Farysia* | 1 | 1 | 1 |
| *Glomosporium* | 1 | 1 | 1 |
| *Melanopsichium* | 1 | | 1 |
| *Melanotaenium* | 3 | 5 | 4 |
| *Moesziomyces* | 1 | | 1 |
| *Nannfeldtiomyces* | 1 | 1 | 1 |
| *Neovossia* | 0 | 2 | 0 |
| *Orphanomyces* | 1 | 1 | 1 |
| *Schizonella* | 2 | | 8 |
| *Schroeteria* | 1 | 1 | 1 |
| *Sorosporium* | 3 | | 10 |
| *Sphacelotheca* | 4 | 6 | 6 |
| *Sporosorium* | 1 | | 4 |
| *Thecaphora* | 3 | 10 | 4 |
| *Tilletia* | 6 | 21 | 9 |
| *Tolyposporium* | 0 | 3 | 0 |
| *Tracya* | 2 | | 2 |
| *Urocystis* | 21 | 44 | 25 |
| *Ustacystis* | 0 | 1 | 0 |
| *Ustilago* | 40 | 38 | 87 |
| *Ustilentyloma* | 0 | 1 | 0 |
| Total | 119 | 217 | 202 |

30 formerly unknown species in Hungary have been reported. Among these there are new to science e.g. *Orphanomyces hungaricus*, *Urocystis tothii* and *Ustilago heleochloae*.

Obviously many changes concerning Hungarian Ustilaginales have taken place during the last 30 years and this necessitated a revision. The following list include the Ustilaginales found in the present territory of Hungary. For collections made after 1950 the appropriate collection data were given. We have also included species not yet found but probably present in Hungary. The host plants and essential symptoms are given as a guide to those who would like to contribute to this interesting group of Hungarian flora.

The nomenclature of the hosts follows EHRENDORFER (1973).

## Check-list of the Hungarian Ustilaginales with their hosts

\+ = Species and hosts found after 1950.
! = Species not yet found, but probably present in Hungary.

### **Anthracoidea** Brefeld

Sori in the ovaries of Carex species (and other Cyperaceae), forming more or less globose, black, hard bodies. Spores single, dark coloured. Germination by a 2-celled promycelium that forms one or more sporidia (basidiospores) on each cell.

**A. arenaria** (H. Syd.) Nannf. [*A. leioderma* (Lagh.) Kochm. et Maj.] — *Carex brizoides* L.; +*C. praecox* Schreb. Comit. Nógrád, Nagykőhegy pr. Bárna, 27. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY.

+**A. caricis** (Pers.) Bref. s. str. — *Carex montana* L., Kőszeg, 20. VI. 1906, A. WAISBECKER.

+**A. caryophylleae** Kukkonen — *Carex caryophyllea* Latourr., Comit. Nógrád, Báránykő pr. Mátrakeresztes, 21. V. 1957, A. HORÁNSZKY.

+**A. michelii** Vánky — *Carex michelii* Host, many collections from the environs of Budapest; Comit. Borsod, Mt. Bükk, Kúthegy pr. Cserépfalu, 4. VI. 1975, MEYER; Comit. Heves, Mt. Bükk, mt. Nagy-Eged pr. Eger, 14. VI. 1981, S. TÓTH.

+**A. pilosae** Vánky — *Carex pilosa* Scop., Comit. Nógrád, Mt. Börzsöny, pr. Diósjenő, 1. VI. 1955, L. BAKSAY, Typus.

**A. pratensis** (H. Syd.) Boidol et Poelt — *Carex flacca* Schreb., Comit. Komárom, pr. Piliscsév, 8. VI. 1959, A. HORÁNSZKY.

**A. subinclusa** (Körner) Bref. — *Carex hirta* L., Comit. Veszprém, Tihany, Külső tó, 30. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY; *C. riparia* Curt., Comit. Zala, Ormánd-puszta pr. Komárváros, 15. VI. 1952, Á. KÁROLYI; Comit. Veszprém, Tihany, Külső tó, 30. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY; Comit. Pest. Mt. Börzsöny, pr. Királyrét, Büdöstó, 10. X. 1978, J. GÖNCZÖL; — 19. VII. 1979, J. GÖNCZÖL, S. TÓTH.

+**A. tomentosae** Vánky — *Carex tomentosa* L., Comit. Borsod, Mt. Bükk, 26. VII. 1909, J. BUDAI.

! **A. angulata** (H. Syd.) Boidol et Poelt — *Carex hirta* L. Obs. *A. angulata* (H. Syd.) Boidol et Poelt (*Cintractia angulata* Zillig) in ZILLIG, Ustil. eur. 1/b, Hungaria, Comit. Pest, Sükösd, VI. 1918, F. GREINICH = *A. subinclusa* (Körner) Bref.

! **A. aspera** (Liro) Kukk. — *Carex appropinquata* Schum., — *C. diandra* Schrk.

! **A. buxbaumii** Kukk. — *Carex hartmanii* Cajander

! **A. echinospora** (Leht.) Kukk. — *Carex gracilis* Curt.

! **A. fischeri** (Karst.) Kukk. — *Carex canescens* L., *C. diandra* Schrk., *C. disticha* Huds.
! **A. inclusa** Bref. — *Carex rostrata* Stokes.
! **A. irregularis** (Liro) Boidol et Poelt — *Carex digitata* L., *C. ornithopoda* Willd.
! **A. karii** (Liro) Nannf. — *Carex echinata* Murr. (*C. stellulata* Good.).
! **A. paniceae** Kukk. — *Carex panicea* L.

**Burrillia** Setchell

Sori in the leaves, petioles and stems of aquatic or paludal plants forming spots punctated by the spore balls embedded in the host tissue. Spore balls many-spored, rather permanent, composed of a pseudoparenchymatous tissue of sterile cells in which the spores are scattered, cortical layer is lacking. Germination after *Tilletia* scheme.

! **B. decipiens** (Wint.) Clint. — *Limnanthemum* sp.

**Doassansia** Cornu

Sori in the leaves, petioles and stems of aquatic or paludal plants as yellowish or brownish areas with numerous, in the host tissue embedded spore balls as very minute brown dots. Spore balls rather permanent, composed of a central mass of spores surrounded by a more or less evident cortex of sterile cells. Germination of *Tilletia* type.

+**D. hottoniae** (Rostr.) De Toni — *Hottonia palustris* L., Comit. Pest, lacus Alsó csikóvári tó pr. Pomáz, 7. IX. 1925, S. Jávorka; lacus Tengerszem pr. Pomáz, 20. VII. 1948, A. Pénzes; Mt. Börzsöny, lacus Büdöstó pr. Szokolya, 27. VIII. 1947, S. Jávorka; —, 26. IX. 1977, J. Gönczöl.
+**D. limosellae** (J. Kze.) Schröt. [*Burrillia limosellae* (J. Kze.) Liro] — *Limosella aquatica* L., Comit. Borsod, Edelény, 7. VIII. 1906, J. Budai.
**D. sagittariae** (Fuck.) C. Fisch. — *Sagittaria sagittifolia* L., Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 26. IX. 1962, S. Tóth; —, 25. VII. 1979, J. Gönczöl, S. Tóth; Comit. Szolnok, pr. Tiszafüred, 11. VI. 1975, S. Tóth, T. et K. Vánky.
! **D. alismatis** (Nees) Cornu — *Alisma lanceolatum* With., *A. plantago-aquatica* L.
! **D. callitriches** Jacks. et Linder — *Callitriche* sp.
! **D. (?) comari** (Berk.) De Toni et Massee — *Comarum palustre* L.
! **D. epilobii** Farl. — *Epilobium palustre* L.
! **D. niesslii** De Toni — *Butomus umbellatus* L.
! **D. peplidis** Bub. — *Peplis* sp.
! **D. utriculariae** P. Henn. — *Utricularia* sp.
! **D. winteriana** P. Magn. — *Lythrum hyssopifolia* L.

**Doassansiopsis** (Setchell) Dietel

Sori in the leaves, petioles, stems or ovaries as spots or swellings with the spore balls embedded in the host tissue. Spore balls rather permanent, com-

posed of a central mass of pseudoparenchymatous sterile cells, surrounded by the firmly united spores and an usually thin cortical layer of sterile cells. Germination after *Tilletia* scheme.

+**D. hydrophila** (A. Dietr.) Lavrov — *Potamogeton nodosus* Poir., Comit. Somogy, pr. Babocsa, 18. IX. 1933, A. Boros: *P. lucens* L., Comit. Somogy, lacus Baláta-tó, 16. VIII. 1963, S. Tóth; *P. natans* L., Comit. Szolnok, Kisújszállás, 23. IX. 1977, S. Tóth.

! **D. horiana** (P. Henn.) Shen — *Sagittaria sagittifolia* L.

! **D. occulta** (Hoffm.) Diet. — *Potamogeton filiformis* Pers., *P. gramineus* L., *P. natans* L. (in the swollen seeds).

! **D. pustulata** Kietel — *Sagittaria* sp.

**Entorrhiza** C. Weber

Sori forming hard, round, pyriform, cylindrical or digitate galls on the roots of different Juncaceae and Cyperaceae. Spore mass light yellow to orange coloured, conglutinated. Spores intracellularly, usually single or in pairs, thick-walled, subhyaline to light yellowish-brown, rather permanently embedded in the host tissue. Germination, where known, by 1–4, aseptate promycelia, each bearing up to 4 terminal, aseptate, slender, curved sporidia (basidiospores). Spores also germinate directly to form septate, branched hyphae without sporidia.

! **E. aschersonia** (Magn.) Lagerh. — *Juncus bufonius* L.

! **E. caricicola** Ferd. et Winge — *Carex* spp., *Juncus* spp.

! **E. caspariana** (Magn.) Lagerh. (= *Er. digitata* Lagerh.) — *Juncus articulatus* L., *J. bufonius* L., *J. tenuis* Willd., *J.* spp.

! **E. cypericola** (Magn.) Weber — *Pycreus flavescens* (L.) Rchb.

! **E. scirpicola** (Corr.) Sacc. et Syd. — *Eleocharis quinqueflora* (F. X. Hartm.) O. Schwarz. [*E. pauciflora* (Lightf.) Link], *Scirpus* spp.

**Entyloma** de Bary

Sori usually on the leaves and stems forming round, angular or elongated, yellowish to brown spots, sometimes constituing galls on the leaves, stems or roots. Spores rather permanently embedded in the host tissue, generally light coloured, usually single or adhering in irregular groups. Spore wall as a rule smooth, often with hyaline gelatinous sheat. Germination of *Tilletia* type.

+**E. bellidis** Krieg. — *Bellis perennis* L., Comit. Veszprém, Keszthely, 8. V. 1976, K. Vánky.

**E. calendulae** (Oudem.) De By. — *Calendula officinalis* L.

+**E. compositarum** Farl. — *Gaillardia aristata* Pursh, Comit. Pest, Gödöllő, 18. VIII. 1954, S. Tóth; Comit. Baranya, Pécs, 11. IX. 1973, M. Glits.

**E. corydalis** De By. — *Corydalis cava* (L.) Schw. et Koerte (*C. bulbosa* sensu Fl. Eur.).

+**E. dahliae** H. et P. Syd. — *Dahlia variabilis* (Willd.) Desf., Budapest, 14. IX. 1938, B. Husz.

**E. eryngii** (Corda) De By. — *Eryngium campestre* L., Comit. Pest, pr. Leányfalu, 23. V. 1972, S. Tóth; Comit. Veszprém, Balatonfüred, 8. VIII. 1974, K. Vánky; Comit. Pest, pr. Felsőpakony, 21. V. 1977, J. Gönczöl; Comit. Pest. pr. Rákoskeresztúr, 31. VIII. 1978, S. Tóth; Comit. Pest, pr. Bénye, 31. VIII. 1978, S. Tóth.

+**E. fergussonii** (Berk. et Br.) Plowr. — *Myosotis scorpioides* L. [*Myosotis palustris* (L.) Nath.], Comit. Pest pr. Ócsa, 17. X. 1980, J. GÖNCZÖL, Á. RÉVAY.

**E. ficariae** Fisch. v. Waldheim [*E. ranunculi* (Bon.) Schröt., *E. ranunculi-repentis* Stern., *E. ranunculi-scelerati* Kochm., *E. ranunculorum* Liro, *E. wroblewskii* Kochm.] — *Ranunculus ficaria* L. [*Ficaria verna* Huds.], Comit. Pest, Gödöllő, 9. V. 1962, E. ZAHORECZ; Comit. Veszprém, Szigliget, arboretum, 7. V. 1964, S. TÓTH; Comit. Veszprém, Mt. Bakony, pr. Eplény, 18. V. 1976, L. ZELLER, S. TÓTH, J. GÖNCZÖL, K. VÁNKY; *R. polyanthemos* L.; +*R. repens* L., Comit. Veszprém, Mt. Bakony, pr. Bakonykoppány, 2. X. 1970, S. TÓTH; Comit. Veszprém, pr. Tihany, lacus Külsőtó, 30. V. 1977, S. TÓTH; *R. sceleratus* L.

**E. fuscum** Schröt. — *Papaver dubium* L., +*P. rhoeas* L., Comit. Pest, pr. Dabas, 13. V. 1964, S. TÓTH; *P. somniferum* L., Comit. Bács-Kiskun, Sükösd, 1926, F. GREINICH.

**E. matricariae** Rostr. — *Tripleurospermum inodorum* (L.) C. H. Schultz [*Matricaria inodora* L.], Comit. Hajdú-Bihar, pr. Berettyóújfalu, 4. VIII. 1974, K. VÁNKY.

**E. microsporum** (Ung.) Schröt. — *Ranunculus repens* L., Comit. Pest, Gödöllő, 11. X. 1966, S. TÓTH; Comit. Pest, Visegrád, 22. V. 1976, K. VÁNKY; Comit. Vas, p. Nagymizdó, 14. IX. 1966, S. TÓTH.

**E. picridis** Rostr. [*E. arnoseridis* H. et P. Syd., *E. leontodontis* H. et P. Syd., *E. hieracii* H. et P. Syd.] — *Hieracium sylvaticum* (L.) L., Comit. Baranya, Pécsvárad, 17. VI. 1950, L. PINTÉR.

**E. serotinum** Schröt. — *Symphytum officinale* L., Comit. Pest, pr. Ócsa, 17. X. 1980, Á. RÉVAY, J. GÖNCZÖL.

**E. thalictri** Schröt. — *Thalictrum minus* L.

+**E. urocystoides** Bub. — *Corydalis cava* (L.) Schw. et Koerte [*C. bulbosa* sensu Fl. Eur.], Comit. Baranya, pr. Pécs, Égervölgy, 15. V. 1962, A. VASS et S. TÓTH; — Mt. Mecsek, mt. Kövestető pr. Magyaregregy, 17. V. 1962, A. VASS et S. TÓTH; —, pr. Zobák, 14. V. 1965, A. VASS.

! **E. achilleae** P. Magn. — *Achillea millefolium* L.

! **E. antennariae** Liro — *Antennaria dioica* (L.) Gärtn.

! **E. arnicale** Ell. et Ev. — *Arnica montana* L.

! **E. aschersonii** (Ule) Wor. — *Helichrysum arenarium* (L.) Mönch. (swellings on the root collar).

! **E. australe** Speg. — *Physalis alkekengi* L., *Solanum nigrum* L.

! **E. bavaricum** H. Syd. — *Senecio rivularis* (W. et K.) DC.

! **E. brefeldi** Krieg. — *Phalaris arundinacea* L.

! **E. bupleuri** Lindr. — *Bupleurum* sp.

! **E. callitrichis** Liro — *Callitriche* spp.

! **E. chelidonii** Cif. — *Chelidonium majus* L.

! **E. chrysosplenii** Schr. — *Chrysosplenium alternifolium* L.

! **E. cichorii** Wrobl. — *Cichorium intybus* L.

! **E. circaeae** Dearn. — *Circaea* sp.

! **E. dactylidis** (Pass.) Cif. — *Agrostis canina* L., *A. stolonifera* L., *A. tenuis* Sibth., *Alopecurus pratensis* L., *Catabrosa aquatica* (L.) P. B., *Cynosurus echinatus* L., *Dactylis glomerata* L., *Deschampsia caespitosa* (L.) P. B., *Festuca ovina* L., *F. rubra* L., *F. rupicola* Heuff., *Holcus lanatus* L., *H. mollis* L., *Phleum pratense* L., *Koeleria gracilis* Pers., *Poa annua* L., *P. bulbosa* L., *P. compressa* L., *P. pratensis* L., *P. trivialis* L., *Puccinellia distans* (L.) Parl., *Trisetum flavescens* (L.) R. et Sch., etc. (lead-coloured to blackish streaks or spots on the leaves).

! **E. davisii** Cif. — *Rudbeckia hirta* L.

! **E. ellisii** Halst. — *Spinacia oleracea* L.

! **E. erigerontis** H. et P. Syd. — *Erigeron canadense* L., *E.* spp.
! **E. eryngii-plani** Cif. — *Eryngium planum* L.
! **E. feurichii** Krieg. — *Lathyrus silvester* L.
! **E. flavum** Cif. — *Sium latifolium* L., *Berula erecta* Coville
! **E. fragosoi** Cif. — *Glaucium corniculatum* (L.) Rudolph.
! **E. fumariae** Schr. — *Fumaria parviflora* Lam., *F. rostellata* Knaf., *F. vaillantii* Lois.
! **E. galinsogae** H. et P. Syd. — *Galinsoga ciliata* (Rafin.) Blake.
! **E. glaucii** Dang. — *Glaucium flavum* Cr.
! **E. henningsianum** H. et P. Syd. — *Samolus valerandi* L.
! **E. hydrocotylis** Speg. — *Hydrocotyle* sp.
! **E. hypochaeridis** Speg. — *Hypochoeris* sp.
! **E. linariae** Schr. — *Linaria genistifolia* (L.) Mill., *L. vulgaris* Mill.
! **E. lini** Oud. — *Linum usitatissimum* L.
! **E. ludwigianum** Syd. — *Chrysanthemum* sp.
! **E. magnusii** (Ule) Wor. [= ? *E. aschersonii* (Ule) Wor.] — *Gnaphalium luteo-album* L., *G. uliginosum* L. (swellings on the root collar).
! **E. magocsyanum** Bub. — *Tordylium maximum* L.
! **E. maireanum** Cif. — *Hypochoeris radicata* L., *H.* spp.
! **E. meliloti** Mc Alp. — *Melilotus officinalis* Lam., *Trigonella foenum-graecum* L.
!**E. myosuri** H. Syd. — *Myosurus minimus* L.
! **E. nubilum** Liro — *Alopecurus pratensis* L.
! **E. nigellae** Cif. — *Nigella damascena* L.
! **E. nymphaeae** (D. Cunn.) Setch. — *Nymphaea alba* L.
! **E. oenanthes** R. Maire (= ? *E. debonianum* Sacc.) — *Oenanthe silaifolia* M. B.
! **E. parvum** Davis — *Eleocharis acicularis* (L.) R. Br.
! **E. pastinacae** Jaap — *Pastinaca sativa* L.
! **E. petuniae** Speg. — *Petunia violacea* Lindl., *P. nyctaginiflora* Juss.
! **E. plantaginis** A. Blytt — *Plantago lanceolata* L., *P. media* L.
! **E. polygoni-amphibii** Savul. — *Polygonum amphibium* L.
! **E. saccardianum** Scalia — *Senecio* sp.
! **E. saniculae** Peck. — *Sanicula* spp.
! **E. schweinfurthii** P. Henn. — *Polygonum patulum* M. B. (*P. monspeliense* Thiébaud in PERS.).
! **E. tanaceti** Syd. — *Tanacetum vulgare* L. [= *Chrysanthemum vulgare* (L.) Bernh.].
! **E. tragopogi** Lagerh. — *Tragopogon orientalis* L.
! **E. trigonellae** J. A. Stev. — *Trigonella foenum-graecum* L.
! **E. uliginis** Speg. — *Centunculus minimus* L.
! **E. veronicae** (Wint.) Lagerh. — *Veronica peregrina* L.
! **E. veronicicola** Lindr. — *Veronica serpyllifolia* L.
! **E. verruculosum** Pass. — *Ranunculus acer* L., *R. lanuginosus* L., *R. sceleratus* L.
! **E. xanthii** C. Mass. — *Xanthium strumarium* L.

## **Farysia** Raciborski

Sori in ovaries of Carex species, forming olive-brown to black-brown, dusty spore mass traversed by numerous, conspicuous, capillitium-like fascicles of sterile hyphae. Spores single, small, variable in form and size, verruculose. Germination by a short promycelium which buds off several cylindrical or spindle-shaped sporidia, or the sporidia are budded off directly from the spores.

**F. thuemenii** (Fisch. v. Waldh.) Nannf. [*F. caricis* (D. C.) Liro] – *Carex riparia* Curt., Comit. Pest, pr. Ócsa, 6. VI. 1979, J. GÖNCZÖL et Á. RÉVAY.

! **F. olivacea** (Jaap) v. Höhnel [non *F. olivacea* (D. C.) H. et P. Syd.] [*F. jaapii* H. et P. Syd.] – *Carex caryophyllea* Latourr., *C. praecox* Schreb.

## Glomosporium Kochman

Sori in hypertrophied ovaries containing a granular-powdery, orange to light brown coloured mass of spore balls. Spore balls many-spored, permanent. Germination after *Tilletia* scheme, with 3–4 terminal, subarcuate sporidia (basidiospores) provided with long spinules.

**G. leptideum** (H. et P. Syd.) Kochm. – *Chenopodium album* L.

! **G. amaranthi** Hirschh. – *Amaranthus chlorostachys* Willd., *A. retroflexus* L.

## Melanopsichium G. Beck

Sori as conspicuous, purplish-black, hard galls in various parts of the host, most frequently in the inflorescence, composed of hypertrophied host tissue and mycelium, with numerous chambres filled by spores embedded in a gelatinous mass. Spores single, conglutinated. Germination of *Ustilago* type.

**M. pennsylvanicum** Hirschh. – *Polygonum lapathifolium* L. Obs. MOESZ mentions in the inflorescence of *Polygonum mite* Schrank too, but the material available in BP contains *Sphacelotheca hydropiperis* only.

## Melanotaenium de Bary

Sori in the vegetative parts forming black, often confluent spots on the leaves and petioles or black galls on the bases of stems or on the roots. Spores embedded in the host tissue, single but often agglutinated, with dark, blackish-brown, smooth wall. Germination of *Tilletia* type.

**M. ari** (Cke) Lgh. – *Arum maculatum* L., Comit. Komárom, Kőhegy pr. Tatabánya, 26. V. 1964, S. TÓTH; Comit. Hajdú-Bihar, Nagyerdő pr. Debrecen, 20. IV. 1965, O. TÓTH; —, 10. V. 1977, O. TÓTH et K. VÁNKY; Comit. Komárom, mt. Pilis pr. Pilisszentlélek, 12. V. 1965, S. TÓTH; —, 19. IV. 1967, S. TÓTH; Arum orientale Bieb., Comit. Fejér, pr. Bodajk, 24. V. 1979, S. TÓTH et J. GÖNCZÖL.

**M. cingens** (G. Beck) P. Magn. – *Linaria genistifolia* (L.) Mill.

+**M. endogenum** (Ung.) De By – *Galium mollugo* L., Comit. Pest, Remetehegy pr. Nagykovácsi, 12. V. 1972, S. TÓTH.

! **M. adoxae** (Bref.) S. Ito – *Adoxa moschatellina* L. (on the roots as dirty-brown swellings).

! **M. hypogaeum** (Tul.) Schellenb. – *Kickxia spuria* (L.) Dum. (large black swellings on the root collar).

! **M. jaapii** P. Magn. – *Teucrium montanum* L. (swellings at the base of the stems).

! **M. koschurnikoveanum** Lavrov – *Galeopsis tetrahit* L. (swellings at the base of the stems and on root collar).

! **M. lamii** Beer – *Lamium album* L. (large swelling on the root collar).

**Moesziomyces** Vánky

Sori in the ovaries, without columella. Spores in manyspored spore balls firmly agglutinated by surface ornaments appearing as irregular meshes, or at the margins as thin irregular wings when the spores are separated. Germination of *Ustilago* type.

+**M. bullatus** (Schröt.) Vánky [*Tolyposporium bullatum* (Schröt.) Schröt.] — *Echinochloa crus-galli* (L.) P. B., Comit. Pest, Mt. Börzsöny, pr. Szokolya, Királyrét, 26. IX. 1977, J. Gönczöl; Comit. Zala, pr. Szentliszló, 27. IX. 1978, J. Gönczöl; Comit. Szolnok, pr. Túrkeve, 8. IX. 1979, J. Gönczöl et Á. Révay; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 20. IX. 1979, J. Gönczöl et Á. Révay.

**Nannfeldtiomyces** Vánky

Sori on aquatic or paludal plants as spots on the leaves and stems in which the spore balls are formed. Spore balls rather permanently embedded in the host tissue, extracellularly, many-spored, composed of a network of branched mycelia in which the spores are scattered, friable and easily decomposed in separate spores; no cortical layer. Spores globose to irregular, light coloured, smooth walled, very loosely held together. Germination of *Tilletia* type.

+**N. sparganii** (Lgh.) Vánky — *Sparganium erectum* L., Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 25. VI. 1979, J. Gönczöl et S. Tóth.

! **N. anomalus** (Crowell) Vánky — *Sparganium minimum* (Hartm.) Fr.

**Neovossia** Körnicke

Sori in scattered, hypertrophied ovaries of Gramineae, filled by a dark, dusty spore mass. Spores single, dark coloured, each provided with a long, hyaline appendage, the rest of the sporogenous hyphae. Germination after *Tilletia* scheme; the number of the basidiospores is very large.

! **N. iowensis** Hume et Hobson [*N. danubialis* Savul.] — *Phragmites communis* Trin.

! **N. moliniae** (Thüm.) Körn. — *Molinia coerulea* (L.) Mönch.

**Orphanomyces** Savile

Sori as black, often confluent crusts on the young leaves, later semi-powdery or granular-powdery. Spores single or in loosely aggregated spore balls, dark coloured. Mycelium systemic-perennial. The infected plants remain sterile. Germination insufficiently known.

+**O. hungaricus** Vánky et Gönczöl — *Carex acuta* L. em. Reich. [*C. gracilis* Curt.], Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 30. VI. 1977, J. Gönczöl. Typus; —, 8. XI. 1978, J. Gönczöl; —, 14. VII. 1979, J. Gönczöl et S. Tóth.

! **O. vankyi** Savile — *Carex acutiformis* Ehrh.

**Schizonella** Schröter

Sori on the leaves of Carex and Kobresia, forming short or long, black, semidusty, pustulate streaks. Spores arise in pairs, loosely held together by a hyaline bridge, easily separating into single spores, or sometimes forming irregular, loose, semipermanent spore balls. Germination of *Ustilago* type.

**Sch. cocconii** (Morini) Liro — *Carex halleriana* Asso.

**Sch. melanogramma** (DC.) Schröt. — *Carex caryophyllea* Latourr., Comit. Pest, pr. Pomáz, 11. VI. 1979, J. GÖNCZÖL et Á. RÉVAY; +*C. digitata* L., Comit. Somogy, Denna-erdő pr. Lipótfa, 5. VI. 1963, S. TÓTH; *C. divulsa* Stokes, +*C. fritschii* Waisb., Comit. Veszprém, Apró-hegyek pr. Keszthely, 11. V. 1963, S. TÓTH; *C. michelii* Host., Comit. Pest, Mt. Pilis pr. Pilisszentkereszt, 18. V. 1960, S. TÓTH; —, 21. V. 1976, A. HORÁNSZKY; Comit. Pest, Nagyszénás pr. Nagykovácsi, 15. X. 1964, S. TÓTH; +*C. montana* L., Comit. Fejér, Mt. Vértes pr. Csákvár, 24. VI. 1965, S. TÓTH; Comit. Pest, mt. Kopaszoldal pr. Nagykovácsi, 1. VII. 1965, S. TÓTH; Comit. Pest, Szarvasszérű pr. Pilisszentlászló, 2. VI. 1972, S. TÓTH; Comit. Veszprém, pr. Pécsely, 18. V. 1976, S. TÓTH et K. VÁNKY; *C. muricata* agg.; *C.* sp. (? *C. michelii* Host) Comit. Pest, Mt. Börzsöny, Királyrét pr. Szokolya, 1. V. 1964, Cs. DOBOLYI; Comit. Komárom, Kőhegy pr. Tatabánya, 26. V. 1964, S. TÓTH.

**Schroeteria** Winter

Sori in the seeds of Veronica species, forming a gray or grayish-black, powdery spore mass. Spores developed in pairs or rarely in threes but often easily separating into single spores. Germination of intermediate type by one or two, short, bottle-like, one-celled promycelia with a terminal chain of globose sporidia (basidiospores), or by a long, septate promycelium bearing laterally and terminally globose sporidia. Sometimes both types of promycelia arise from the same spore.

**Schr. decaisneana** (Boud.) De Toni — *Veronica hederifolia* L., Comit. Nógrád, Nagykőhegy pr. Bárna, 27. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY.

! **Schr. delastrina** (Tul.) Wint. — *Veronica agrestis* L., *V. arvensis* L., *V. praecox* All., *V. triphyllos* L., *V. verna* L.

Obs. **Schr. delastrina** (Tul.) Wint. — *Veronica triloba* Opiz in Moesz 1950. p. 146 = *Schr. decaisneana* (Boud.) De Toni.

**Sorosporium** Rudolphi

Sori destroying the flowers or the whole inflorescence producing a light yellowish-brown to dark brown, dusty mass of spore balls. Spore balls composed of medium to large number of fertile spores more or less loosely held together. Germination of *Ustilago* type. It is a rather heterogeneous genus and this fact seems to justify its division.

**S. cenchri** P. Henn. [*S. syntherismae* (Peck.) Farl., *S. cenchri* P. Henn. var. *levis* Ubrizsy et Vörös] — *Cenchrus incertus* M. A. Curt. [= *C. pauciflorus* Benth.] Comit. Bács-

Kiskun, Talfája pr. Kecskemét, 27. IX. 1967, G. Ubrizsy; Comit. Pest. Csévharaszt, 27. IX. 1977, J. Gönczöl; Comit. Bács-Kiskun, pr. Fülöpháza, 25. VI. 1979, J. Gönczöl et S. Tóth.

**S. holci-sorghi** (Riv.) Moesz [*Sphacelotheca reiliana* Clinton] — +*Sorghum bicolor* (L.) Moench, Comit. Bács-Kiskun, Csávoly pr. Baja, 12. VIII. 1910, J. Nagy; +*S. halepense* (L.) Pers., Comit. Fejér, Martonvásár, 1956, 1959, ap. Podhradszky, n. v.; *Zea mays* L.

**S. saponariae** Rudolphi [*S. melandryi* H. Syd., *S. purpureum* (Hazsl.) Liro, *S. silenes-inflatae* (Zigno) Ciferri] — +*Dianthus carthusianorum* L., Budapest, VI. 1876, Gy. Szépligeti; *D. pontederae* Kern., Comit. Veszprém, pr. Uzsa, 22. VI. 1968, S. Tóth et K. Vánky; *Saponaria officinalis* L., Comit. Veszprém, Szentgyörgy-hegy pr. Tapolca 24. VI. 1948, S. Tóth; Comit. Pest, pr. Isaszeg, 9. VII. 1976, S. Tóth; *Silene alba* (Mill.) E. H. L. Krause [*Melandrium album* (Mill.) Garcke]; *Silene vulgaris* (Moench) Garcke [*S. inflata* Sm., *S. cucubalus* Wibel], Comit. Somogy, Balatonberény pr. Keszthely, 23. VI. 1968, S. Tóth et K. Vánky; *Petrorhagia saxifraga* (L.) Lk. [*Tunica saxifraga* (L.) Scop.], Comit. Veszprém, Szépkilátó pr. Keszthely, 22. VI. 1968, S. Tóth et K. Vánky.

## Sphacelotheca de Bary

Sori in the ovaries or in the whole inflorescence, provided with a fungal peridium of hyaline cells which ruptures irregularly to expose the dusty spore mass and the central columella composed of fungal cells similar to those of the peridium. The components of the sorus develop from the base of the sorus (basifugally). Spores single, small to medium sized, dark coloured. Immature spores catenulate and connected by disjunctors. Germination of *Ustilago* type.

**S. andropogonis** (Opiz) Bubák [*S. ischaemi* Clinton] — *Bothriochloa ischaemum* (L.) Keng. [*Andropogon ischaemum* L.] Comit. Pest, Majdánhegy pr. Pomáz, 16. VI. 1946, S. Tóth; —, Kőhegy pr. Pomáz, 19. VI. 1956, et 17. IX. 1956, J. Podhradszky; Comit. Fejér, Tordas, 3. VII. 1962, J. Podhradszky; Comit. Pest, Nagykevély, 5. VII. 1963, A. Horánszky; Comit. Veszprém, pr. Balatonfüred, 15. X. 1968; Comit. Baranya, Szársomlyó pr. Nagyharsány, 4. VII. 1971, S. Tóth; Comit. Komárom, Korpás-hegy pr. Süttő, 24. VIII. 1973, S. Tóth; Comit. Pest, Törökugrató pr. Törökbálint, 20. VI. 1977, J. Gönczöl et S. Tóth; —, pr. Nagymaros, 25. IX. 1979, J. Gönczöl.

**S. destruens** (Schlecht.) Stev. et Johns. [*S. panici-miliacei* (Wint.) Bubák] — *Panicum miliaceum* L., Comit. Veszprém, Keszthely, VIII. 1960, J. Podhradszky; Comit. Pest, Gödöllő, 28. VII. 1964, E. Zahorecz.

**S. hydropiperis** (Schum.) De Bary — *Polygonum hydropiper* L., Comit. Veszprém, Somhegy pr. Bakonybél, 1954, P. Tallós; Comit. Baranya, Mt. Mecsek, Szuadóvölgy, 10. X. 1958, S. Tóth et A. Vass; *P. mite* Schrank, Comit. Vas, pr. Nagymizdó, 14. IX. 1966, S. Tóth; *P. persicaria* L., Comit. Pest, Soroksár, 25. IX. 1960, V. Csapody; Comit. Baranya, pr. Sikonda, 17. VIII. 1967, A. Vass.

**S. montaniensis** (Ell. et Holw.) Clinton [*S. strangulans* Issatschenko] — *Eragrostis minor* Host [*E. poaeoides* PB.] Comit. Hajdú-Bihar, pr. Debrecen, 1952, L. Dobó.

! **S. constantineanui** Savul. — *Alopecurus aequalis* Sobol. (in the ovaries).

! **S. digitariae** (Kunze) Clint. — *Digitaria sanguinalis* (L.) Scop. (in the ovaries).

! **S. diplospora** (Ell. et Ev.) Clint. — *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) PB. (in the ovaries).

! **S. fagopyri** H. et P. Syd. — *Fagopyrum esculentum* Mönch (in the ovaries).
! **S. melicae** (Sor.) Cif. — *Melica ciliata* L. (in the ovaries).
! **S. tragi** Savul. — *Tragus racemosus* (L.) All. (in the inflorescence, hidden by the leaves).

**Sporisorium** Ehrenberg ap. Link

Sori in the flowers or in the whole inflorescence, provided with a peridium, composed of interwoven hyphae and host tissues, which rupture irregularly to expose the dark brown spore mass and one to many columellae, composed of host tissues permeated by hyphae. Spores single, at first somewhat agglutinated, later pulverulent, dark coloured, intermixed by groups or chains of hyaline, sterile (partitioning) cells. Spores and sterile cells differentiate from hyphae growing centrifugally from the columella of young sori. Germination of *Ustilago* type.

**Sp. sorghi** Ehrenb. [*Sphacelotheca sorghi* (Link) Clint.] — *Sorghum halepense* (L.) Pers.; *S. dochna* (Forsk.) Snow.; *S. saccharatum* (L.) Mönch, Comit. Pest, Gödöllő, IX. 1954, L. Pósa; *S. bicolor* (L.) Mönch, Comit. Fejér, Martonvásár, 31. X. 1960, J. Podhradszky.

**Thecaphora** Fingerhuth

Sori in various parts of the host, mostly in reproductive organs, or sometimes forming pustules on the stems, at maturity with a granular-dusty mass of spore balls. Spore balls permanent, composed of few to many fertile spores. Germination, so far as is known, by a septate promycelium bearing an apical, elongated basidiospore, or producing hyphae from the cells of the promycelium.

**Th. aterrima** Tul. — +*Carex caryophyllea* Latourr. Comit. Veszprém, Mt. Bakony, pr. Pécsely, 18. V. 1976, L. Zeller, S. Tóth, J. Gönczöl, K. Vánky.

**Th. deformans** Dur. et Mont. (*Th. affinis* Schneid.) — *Astragalus glycyphyllos* L., Comit. Veszprém, mt. Badacsony, 29. VI. 1946, A. Károlyi; Comit. Baranya, Mt. Mecsek pr. Hosszúhetény, 3. IV. 1968, S. Tóth; Comit. Heves, Mt. Bükk pr. Nagyvisnyó, 24. VII. 1969, S. Tóth; —, Mt. Mátra pr. Mátrafüred, 14. VII. 1972, S. Tóth; —, Mt. Bükk pr. Felsőtárkány, 6. IX. 1972, S. Tóth; —, Mt. Mátra pr. Mátraszentimre, 31. VII. 1975, S. Tóth; Comit. Nógrád, Pogányvár, 16. VII. 1977, S. Tóth.

**Th. seminis-convolvuli** (Desm.) S. Ito — *Calystegia sepium* (L.) R. Br., Comit. Pest, Gödöllő, 21. III. 1965, S. Tóth et K. Vánky; Comit. Veszprém, pr. Balatonfüred, 8. VIII. 1974, K. Vánky; *Convolvulus arvensis* L., Debrecen, 10. et 12. VIII. 1966, O. Tóth.

! **Th. androsaces** (Karst.) Gutner — *Androsace maxima* L. (in the seeds).
! **Th. genistae-tinctoriae** (nom. nud.) — *Genista tinctoria* L. (in the seeds).
! **Th. lathyri** Kühn — *Lathyrus pratensis* L., L. spp. (in the seeds).
! **Th. lithospermi** Vánky et Nannf. — *Lithospermum officinale* L.
! **Th. ? oligospora** Cocc. — *Carex digitata* L., *C. praecox* Schreb. (black crust on the leaves).
! **Th. pimpinellae** Juel — *Pimpinella saxifraga* L. (in the seeds).
! **Th. pustulata** Clint. — *Bidens* sp. (swellings on the stems, usually at nodes).
! **Th. trailii** Cooke — *Carduus* and *Cirsium* spp. (in the flower heads).
! **Th. trigonellae** Schwarzm. — *Trigonella* sp. (in the seeds).
! **Th. viciae** Bubák — *Vicia cracca* L., *V.* spp. (in the seeds).

**Tilletia** Tulasne

Sori usually in the ovaries producing "bunt balls" or sometimes in the leaves and stems of *Gramineae* (rarely of other families), forming streaks, seldom swellings. Spore mass semi-agglutinated to powdery in the ovaries, those in the vegetative parts rather permanently embedded, light to dark brown coloured, mostly with foetid smell due to trimethylamine. Spores single, of medium to large size, frequently with a gelatinous sheath, usually intermixed with hyaline, single sterile cells. Infection systemic. Germination by a promycelium which bears a terminal cluster of elongated sporidia (basidiospores).

**T. caries** (D.C.) Tul. [*T. tritici* (Bjerk.) R. Wolff.] — *Triticum aestivum* L. em. Fiori et Paol., rather common.

**T. controversa** Kühn. [*T. nanifica* (Wagn.) Savul., *T. tritici* (Bjerk.) Wint. sensu Savul., *T. tritici-repentis* (D.C.) Liro] — +*Agropyron pectinatum* (M. B.) P. B. (*A. cristatum* auct.) Comit. Komárom, Környe, V. 1961, A. Pénzes; *A. intermedium* (Host.) PB., *A. repens* (L.) PB.; *Triticum aestivum* L. em. Fiori et Paol. (not rare).

**T. intermedia** (Gassner) Savul. [*T. laevis*×*T. caries*] — *Triticum aestivum* L. em. Fiori et Paol., Podhradszky 1966, p. 170, from many localities.

**T. laevis** Kühn [*T. foetida* (Bauer) Liro] — *Triticum aestivum* L. em. Fiori et Paol. (frequent).

+**T. lepturi** Sigr. — *Pholiurus pannonicus* (Host) Trin. [*Lepturus pannonicus* (Host) Kunth] Comit. Szolnok, Ecsegfalva, Templomzug, 1949, G. Ubrizsy et J. Podhradszky.

+**T. separata** Kunze — *Apera spica-venti* (L.) PB., Comit. Borsod-Abaúj-Zemplén, Végardó pr. Sárospatak, 9. VII. 1959, J. Podhradszky; Comit. Zala, Bak, 25. VI. 1971, F. Szekeres.

(**T. tritici** (Bjerk.) R. Wolff. = *T. caries* (DC.) Tul. — sensu auct. plur., non sensu Savul. q. e. *T. controversa* Kühn.)

Sori in the ovaries.

! **T. bornmuelleri** P. Magn. *Taeniatherum asperum* (Simk.) Nevski.

! **T. brachypodii** Mundkur — *Brachypodium sylvaticum* (Huds.) PB.

! **T. bromi** (Brockm.) Nannf. — *Bromus erectus* Huds., *B. japonicus* Thunb. ex Murray, *B. mollis* L., *B. racemosus* L., *B. rigidus* Roth, *B. secalinus* L., *B. squarrosus* L., *B. sterilis* L., *B. tectorum* L., *Festuca rubra* L.

! **T. cerebrina** Ell. et Ev. — *Aira caryophyllea* L., *Briza* sp., *Deschampsia caespitosa* (L.) PB.

! **T. corona** Scrib. — *Leersia oryzoides* (L.) Sw.

! **T. elymi** Diet. et Holw. — *Elymus* spp.

! **T. goloskokovii** Schwarzm. — *Apera interrupta* (L.) PB.

! **T. holci** (Westerd.) De Toni — *Anthoxanthum odoratum* L., *Holcus lanatus* L., *H. mollis* L.

! **T. koeleriae** Mundk. — *Koeleria pyramidata* agg.

! **T. kuznetzoviana** Schwarzm. — *Phleum phleoides* (L.) Karst.

! **T. lolii** Auersw. — *Lolium multiflorum* Lam., *L. perenne* L., *L. remotum* Schrank, *L. temulentum* L., *Dasypyrum villosum* (L.) Borb. [= *Haynaldia villosa* (L.) Schur].

! **T. maclagani** (Berk.) G. P. Clint. — *Digitaria sanguinalis* (L.) Scop., *Panicum* spp.

! **T. pallida** G. W. Fischer — *Agrostis canina* L., *A.* spp.

! **T. paradoxa** Jacz. — *Phleum* sp., *Poa* sp.

! **T. poae** P. Nag. — *Poa nemoralis* L.

! **T. secalis** (Corda) Körn. — *Secale cereale* L.

! **T. sphaerococca** (Wallr.) Fisch. v. Waldh. (= *T. decipiens*) — *Agrostis canina* L., *A. stolonifera* L., *A. tenuis* Sibth.

Sori on the leaves and stems.

! **T. earlei** Griff. — *Agropyron repens* (L.) PB. (swellings on the upper internodes).
! **T. flectens** Lagerh. — *Deschampsia flexuosa* (L.) Trin. (in twisted leaves).
! **T. olida** (Riess) Wint. — *Brachypodium pinnatum* (L.) PB., *B. sylvaticum* (Huds.) PB.
! **T. sesleriae** Juel — *Sesleria uliginosa* Opiz (light brown, long streaks on the leaves).

## **Tolyposporium** Woronin

Sori in the inflorescences and vegetative parts, forming naked, black, granular-agglutinated mass of spore balls. Spore balls permanent, composed of few to many fertile spores. Germination as in *Ustilago*.

! **T. junci** Lind — *Juncus bufonius* L. (in the inflorescences and culms).
! **T. kochianum** Gäum. — *Schoenus* sp. (in the inflorescence).
! **T. ? montiae** Rostr. — *Montia fontana* L. (brownish black spots on the leaves and stems).

## **Tracya** H. et P. Sydow

Sori in the vegetative parts of aquatic plants, forming finely punctate spots with the spore balls embedded in the host tissue. Spore balls rather permanent, composed of a central network of branched, septate, hardened mycelia, and a peripheral layer of firmly united spores. Germination after *Tilletia* scheme.

+**T. hydrocharidis** Lagh. — *Hydrocharis morsus-ranae* L., Comit. Somogy, lacus Baláta tó pr. Kaposvár, 16. VIII. 1963, S. Tóth; Comit. Bács-Kiskun, Tőserdő, 8. XI. 1978, J. Gönczöl; Comit. Hajdú-Bihar, pr. Nagyiván, 2. IX. 1980, J. Gönczöl.

+**T. lemnae** (Setch.) H. et P. Syd. — *Spirodela polyrrhiza* (L.) Schleiden (*Lemna polyrrhiza* L.), Comit. Veszprém, Vöröstó pr. Nagyvázsony, 21. VII. 1927, S. Jávorka; Comit. Pest, Mt. Börzsöny, Büdöstó pr. Királyrét, supra Szokolya, 20. II. 1978, 18. IX. et 10. X. 1978, J. Gönczöl; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 8. XI. 1978, J. Gönczöl.

## **Urocystis** Rabenh. (*Tuburcinia* Fries)

Sori in the leaves, stems, rarely in the ovaries or in the roots forming streaks, swellings or galls, with brownish-black or black, usually powdery spore mass. Spore balls permanent composed of one to numerous dark coloured, fertile spores, invested more or less completely by paler sterile cells. Germination of *Tilletia* type.

**Ur. agropyri** (Preuss) Fisch. v. Waldh. — *Agropyron repens* (L.) PB. [*Elytrigia repens* (L.) Desv.], Comit. Békés, Szarvas, 11. V. 1959, J. Podhradszky; Comit. Győr-Sopron, Mosonmagyaróvár, 19. V. 1959, J. Podhradszky; Comit. Bács-Kiskun, Kalocsa, VI. 1963, —; Comit. Veszprém, pr. Tihany, 30. V. 1977, J. Gönczöl, S. Tóth, L. Zeller, K. Ványky; Comit. Szolnok, pr. Tiszafüred, 29. VI. 1978, T. et K. Ványky.

**Ur. anemones** (Pers. ex Pers.) Wint. — *Anemone nemorosa* L. Comit. Vas, pr. Horvát-Nádalja, 11. V. 1971, Z. Toborffy; —, pr. Szalafő, 25. IV. 1976, A. Vass, S. Tóth, E. Horváth, M. Naszádos; —, Magyarszombatfa, 25. V. 1976, A. Vass, S. Tóth, M. Naszádos.

+**Ur. arrhenatheri** (Kupr.) Savul. — *Arrhenatherum elatius* (L.) J. et K. Presl, Comit. Győr-Sopron, Mosonmagyaróvár, 24. V. 1956, et VI. 1956, J. PODHRADSZKY.

+**Ur. bromi** (Lavr.) Zundel — *Bromus inermis* Leys., Comit. Győr-Sopron, Mosonmagyaróvár, VI. 1883, Gy. LINHART, sub *U. occulta* (Wallr.) Rabenh.

**Ur. colchici** (Schlecht.) Rabenh. — *Colchicum arenarium* W. et K.; *C. autumnale* L., Comit. Győr-Sopron, Szany, VI. 1959, J. LEHOCZKY; Comit. Baranya, Bisse, 30. IV. 1965, S. TÓTH.

**Ur. ficariae** (Liro) Moesz — *Ranunculus ficaria* L. [*Ficaria verna* Huds.], Comit. Veszprém, 8. V. 1976, K. VÁNKY —, Mt. Bakony pr. Bakonybél, 24. V. 1979, J. GÖNCZÖL et S. TÓTH.

**Ur. filipendulae** (Tul.) Schröt. — *Filipendula vulgaris* Moench [*F. hexapetala* Gilib.], Budapest, VII. 1881, Gy. SZÉPLIGETI.

**Ur. floccosa** (Wallr.) Henders. [*U. hellebori-viridis* (D. C.) Moesz] — *Helleborus dumetorum* W. et K., Comit. Fejér, Alcsut, 27. V. 1962, V. CSAPODY; —, Mt. Vértes, Kőhányáspuszta pr. Csákvár, 9. V. 1968, S. TÓTH; *H. odorus* W. et K., Comit. Baranya, Mt. Mecsek, 13. V. 1959, A. VASS; —, pr. Geresd, 31. V. 1961, A. VASS; —, pr. Páfrányos, 16. V. 1962, A. VASS et S. TÓTH; —, Kövestető pr. Magyaregregy, 17. V. 1962, A. VASS et S. TÓTH.

+**Ur. gladiolicola** Ainsw. [*U. gladioli* (Requien) W. G. Smith] — *Gladiolus* sp. cult. (1959, 1960, M. DOBÓ (1961), n.v.

+**Ur. irregularis** (Wint.) Savul. — *Aconitum vulparia* Rchb. (*A. lycoctonum* L. ssp. *vulparia*), Comit. Pest, Mt. Pilis pr. Pilisszentkereszt, 26. VI. 1966 et 19. V. 1970, S. TÓTH; Comit. Komárom, Mt. Pilis, Feketekő, 21. V. 1969, S. TÓTH.

+**Ur. kmetiana** P. Magn. — *Viola arvensis* Murr., Comit. Fejér, Mt. Vértes pr. Csákvár, Lóállástető, 15. VI. 1978, S. TÓTH et J. GÖNCZÖL.

**Ur. leimbachii** Örtel — +*Adonis aestivalis* L., Comit. Pest, pr. Tárnok, 21. VI. 1968, S. TÓTH et K. VÁNKY; *A. vernalis* L., Comit. Pest, Érd, 3. VI. 1964, S. TÓTH; —, 9. VI. 1965, Cs. DOBOLYI et S. TÓTH.

**Ur. muscaridis** (Niessl) Zundel — *Muscari comosum* (L.) Mill.

**Ur. occulta** (Wallr.) Rabh. — *Secale cereale* L.

**Ur. ornithogali** Körnicke — *Ornithogalum umbellatum* L., Comit. Veszprém, pr. Tihany, 18. V. 1976, L. ZELLER, S. TÓTH, J. GÖNCZÖL, K. VÁNKY; Comit. Nógrád, pr. Kisterenye, 27. V. 1977, A. HORÁNSZKY, S. TÓTH, J. GÖNCZÖL, L. ZELLER, K. VÁNKY; Comit. Fejér, Mt. Vértes pr. Csákvár, Kőhányáspuszta, 21. V. et 15. VI. 1978, J. GÖNCZÖL.

**Ur. polygonati** (Lavr.) Zundel — *Polygonatum multiflorum* (L.) All., pr. Budapest, Normafa, 15. V. 1949, J. LEHOCZKY; *P. odoratum* (Mill.) Druce [*P. officinale* All.], Comit. Pest, Remetehegy pr. Nagykovácsi, 19. IV., 21. V. 1974 et 10. V. 1975, S. TÓTH; —, 4. V. 1976 et 24. V. 1977, S. TÓTH, J. GÖNCZÖL et K. VÁNKY.

**Ur. primulicola** P. Magn. [*Ginaniella primulae* (Rostr.) Cif.] — *Primula veris* L., Mt. Bükk, mt. Tarkő, 5. VII. 1961, A. HORÁNSZKY; Comit. Borsod-Abaúj-Zemplén, Mt. Gerecse, mt. Nagyteke pr. Alsóvadász, 2. VIII. 1961, M. KOMLÓDI; Comit. Fejér, mt. Haraszt pr. Csákvár, 23. X. 1963, et 14. VII. 1965, S. TÓTH; Comit. Heves, Mt. Bükk, mt. Galyakopasza pr. Bélapátfalva, 4. VII. 1966, S. TÓTH et A. HORÁNSZKY; Comit. Borsod-Abaúj-Zemplén, Odorvár pr. Bükkzsérc, 5. VII. 1966, A. HORÁNSZKY, S. TÓTH; —, Háromkő pr. Répáshuta, 6. VII. 1966, S. TÓTH; Comit. Fejér, Mt. Vértes, mt. Lóállástető pr. Csákvár, 5. VIII. 1976, S. TÓTH et G. TURCSÁNYI; —, pr. Csákvár, 15. VI. 1978, J. GÖNCZÖL, S. TÓTH; —, Mt. Vértes, pr. Csókakő 29. VI. 1979, S. TÓTH.

**Ur. pulsatillae** (Bub.) Moesz — *Pulsatilla grandis* Wender, Comit. Heves, mt. Nagy-Eged pr. Eger, 6. VII. 1965, S. TÓTH; Comit. Veszprém, pr. Tihany, 30. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY; Comit. Heves, Mt. Mátra, Tugár-rét pr. Mátrakeresztes, 16. VII. 1981, S. TÓTH.

**Ur. ranunculi** (Lib.) Moesz — *Ranunculus repens* L., Comit. Pest, Gödöllő, Kastélypark, 15. VI. 1965 et 11. X. 1966, S. Tóth; Comit. Veszprém, Mt. Bakony, Cuha-völgy pr. Zirc, 28. IX. 1968, S. Tóth; Comit. Pest, pr. Kistarcsa, 1. VI. 1977, S. Tóth; Comit. Nógrád, pr. Pásztó, 16. VII. 1977, S. Tóth.

**Ur. sternbergiae** Moesz — *Sternbergia colchiciflora* W. et K., Comit. Pest, Remetehegy pr. Nagykovácsi, 10. V. 1975, S. Tóth; —, Sashegy, 12. V. 1979, J. Gönczöl et T. Szerdahelyi.

+**Ur. tothii** Vánky — *Juncus compressus* Jacq., Comit. Heves, Hortobágy, Zámpuszta pr. Nagyiván, 19. VI. 1974, S. Tóth, Typus; Comit. Pest, pr. Bugyi, 22. VI. 1978, J. Gönczöl et S. Tóth.

! **Ur. alopecuri** Frank — *Alopecurus pratensis* L. (streaks on the leaves and culms).

! **Ur. atragenes** (Liro) Zundel — *Clematis alpina* (L.) Mill. (vesicles on the leaves).

! **Ur. beckmanniae** Brezschn. — *Beckmannia eruciformis* (L.) Host (streaks on the leaves and culms).

! **Ur. bolivari** Bub. et Frag. — *Lolium perenne* L. (streaks on the leaves and culms).e

! **Ur. brassicae** Mundk. — *Brassica rapa* L., *B.* spp. (wart-like lead-coloured galls on th roots).

! **Ur. calamagrostidis** (Lavrov) Zundel — *Calamagrostis arundinacea* (L.) Roth. (streaks on the leaves and culms).

! **Ur. carcinodes** (Berk. et Curt.) Fisch. v. Waldh. — *Actea spicata* L., *Cimicifuga europaea* Schipcz. [= *C. foetida* auct.] (spots, swellings on the leaves and stems).

! **Ur. coralloides** Rostr. — *Lepidium perfoliatum* L., *L. ruderale* L., *Matthiola* sp., *Arabis glabra* (L.) Bernh. (rounded or coral-like swellings on the roots).

! **Ur. dactylidina** (Lavrov) Zundel — *Dactylis glomerata* L. (streaks on the leaves).

! **Ur. eranthidis** (Pass.) Ainsw. et Samps. — *Eranthis hyemalis* (L.) Salisb. (vesicles on the leaves and petioles).

! **Ur. erythronii** Clint. — *Erythronium* sp. (minute oblong, often coalescent, lead-coloured swellings on the leaves).

! **Ur. fischeri** Körn. — *Carex acuta* L., *C. bigelowii* Torr. ex Schwein., *C. flacca* Schreb. [= *C. glauca* Scop.], *C. hirta* L., *C. lasiocarpa* Ehrb., *C. leporina* L., *C. nigra* (L.) Reich. (*C. goodenowii* J. Gay), *C. pallescens* L., *C. panicea* L., *C. rostrata* Stokes ex With., *C. vesicaria* L. (long streaks on the leaves).

! **Ur. fraserii** Clinton et Zundel— *Stipa* spp. (confluent streaks surrounding the upper, twisted internodes).

! **Ur. galanthi** Pape — *Galanthus nivalis* L. (vesicles on the leaves).

¡ **Ur. granulosa** G. P. Clint. — *Stipa* spp. (in the spikelets).

¡ **Ur. jaapiana** Sacc. — *Ruscus aculeatus* L. (swellings on the young twigs and subterranean stems).

! **Ur. johansonii** (Lagh.) P. Magn. — *Juncus bufonius* L. (bulbous swellings on the base of leaves).

! **Ur. junci** Lagh. — *Juncus filiformis* L. (in the culms which rupture longitudinally).

! **Ur. komarovii** (Lavrov) Zundel — *Isopyrum* sp. (swellings on the leaves and petioles).

! **Ur. lagerheimii** Bubák — *Juncus compressus* Jacq. (swollen, often coalescent streaks on the stems and on the base of the leaves).

! **Ur. leucoji** Bubák — *Leucojum vernum* L. (vesicles on the leaves).

! **Ur. luzulae** (Schröt.) Wint. — *Luzala multiflora* (Ehrh. Retz.) Lej., *L. pilosa* (L.) Willd. (long, often coalescent streaks on the leaves).

! **Ur. magica** Pass. (= *U. allii* Schellenb. = *U. cepulae* Frost) — *Allium* spp. (vesicles on the leaves and bulbs).

! **Ur. melicae** (Lagerh.) Zundel — *Melica nutans* L., *M. uniflora* Retz. (streaks on the leaves).

! **Ur. miyabeana** (Tog.) S. Ito — *Convallaria majalis* L. (blister-like spots on the leaves and leaf-sheats).

! **Ur. monotropae** (Fr.) Fisch. v. Waldh. — *Monotropa hypopitys* L. (in the roots and stems).
! **Ur. orobanches** (Mérat) Fisch. v. Waldh. — *Orobanche ramosa* L. (in the swollen roots and subterranean part of the stem).
! **Ur. paridis** (Ung.) Thüm. — *Paris quadrifolia* L. (swellings on the stems and petioles and lead-coloured spots on the leaves).
! **Ur. poae** (Liro) Padw. et Khan — *Poa annua* L., *P. compressa* L., *P. pratensis* L. (long streaks on the leaves).
! **Ur. poae-palustris** Vánky — *Poa palustris* L. (on the leaves and on the upper part of the stems, often coalescent streaks).
! **Ur. ranunculi-auricomi** (Liro) Zundel — *Ranunculus auricomus* L. (blister-like swellings on the leaves, petioles and stems).
! **Ur. ranunculi-lanuginosi** (D. C.) Zundel — *Ranunculus lanuginosus* L. (pustules on the leaves).
! **Ur. roivaineni** (Liro) Zundel — *Anthoxanthum odoratum* L. (streaks on the leaves).
! **Ur. schizocaulon** (Ces.) Zundel — *Odontites lutea* (L.) Clairv. (spindle-shaped, longitudinally bursting swellings, affecting also the leaves).
! **Ur. scillae** (Cif.) Zundel — *Scilla bifolia* L. (vesicles on the leaves).
! **Ur. sophiae** Griff. — *Sophia* (= *Descurainia*) spp. (swellings on the roots).
! **Ur. sorosporoides** Körn. — *Thalictrum* spp. (vesicles or swellings on the leaves, petioles and stems).
! **Ur. stipae** Mc Alp. — *Stipa* spp. (streaks on the leaves).
! **Ur. syncocca** (L. A. Kirchn.) Lindeb. — *Hepatica nobilis* Schreb. (vesicles on the leaves).
! **Ur. triseti** (Cif.) Zundel — *Trisetum flavescens* (L.) PB. (streaks on the leaves).
! **Ur. tritici** Körn. — *Triticum aestivum* L. em. Fiori et Paol. (long streaks on the leaves and culms).
! **Ur. trollii** Nannf. — *Trollius europaeus* L. (blister-like swellings on the petioles and leaves).
! **Ur. ulei** P. Magn. ap. Rabenh. [= *U. macrospora* (Desm.) Liro] — *Festuca* spp. (long streaks on the leaves).
! **Ur. violae** (Sow.) Fisch. v. Waldh. — *Viola odorata* L., *V.* spp. (bullate swellings on the leaves and petioles).

### **Ustacystis** Zundel

Sori in the leaves producing swellings of the veins, at first covered by epidermis which ruptures longitudinally to expose the dark brown, semi-agglutinated spore mass. Spores produced singly or in few-spored spore balls which are composed of fertile spores and sometimes with single, lighter coloured sterile cells, resembling *Urocystis* but spore germination as in *Ustilago*.

! **U. waldsteiniae** (Peck) Zundel — *Waldsteinia geoides* Willd., *Geum* sp.

### **Ustilago** (Persoon) Roussel

Sori in various part of the hosts (ovaries, anthers, flowers, inflorescences, leaves, stems and seldom roots), forming dusty, usually dark, blackish, olivaceous or purplish-brown, sometimes light coloured spore mass. Spores single, small to medium in size. Spore germination by a septate promycelium producing only infection-threads or with sporidia formed laterally and terminally.

+**U. anomala** J. Kze. ex Wint. — *Polygonum dumetorum* L. Comit. Heves, Mt. Bükk, Lökbérc pr. Felsőtárkány, 19. VII. 1980, S. Tóth; Comit. Fejér, Mt. Vértes, Haraszt-hegy pr. Csákvár, 1. VIII. 1980, S. Tóth; Comit. Heves, Mt. Bükk, Várhegy pr. Felsőtárkány, 21. VIII. 1980, S. Tóth.

**U. avenae** (Pers.) Jensen [incl. *U. decipiens* (Wallr.) Liro = *U. perennans* Rostr.] — *Arrhenatherum elatius* (L.) J. et K. Presl, Comit. Hajdú-Bihar, Pallag pr. Debrecen, 27. V. 1947, J. Zsigmond; Comit. Veszprém, Keszthely, 1. VI. 1954, J. Podhradszky; Comit. Békés, Bánkút, 1955, J. Podhradszky; Budapest, Lágymányos, 19. VI. 1956, A. Pénzes; Comit. Veszprém, Keszthely, 28. V. 1959, J. Podhradszky; *Avena sativa* L. Comit. Pest, pr. Pesthidegkút, 12. VII. 1949, J. Bánhegyi; —, Gödöllő, 26. VI. 1964, E. Zahorecz.

**U. bullata** Berk. (*U. bromi-arvensis* Liro, *U. bromi-mollis* Liro, *U. bromivora* Fisch. v. Waldh.] — *Bromus commutatus* Schrad., +*B. inermis* Leyss., Comit. Bács-Kiskun, Kecskemét, 1954, J. Podhradszky; *B. mollis* L. [*B. hordeaceus* L.], Comit. Szolnok, pr. Tiszafüred, 29. VI. 1978, T. et K. Vánky; *B. secalinus* L., Comit. Vas, pr. Zalaháshágy-Szőcze, 9. VII. 1954, A. Károlyi; *B. sterilis* L., Comit. Pest, mt. Rókahegy pr. Törökbálint, 30. V. 1946, J. Stieber; Comit. Veszprém, Badacsony, 29. VI. 1946, A. Károlyi; Comit. Pest, Szentendre, 27. V. 1951, J. Lehoczky; Comit. Fejér, Martonvásár, 15. VI. 1956, E. Szabó; Comit. Pest, Pomáz, 19. VI. 1956, J. Podhradszky; Comit. Baranya, Mt. Mecsek pr. Pécs, 25. VI. 1968, S. Tóth et K. Vánky; Comit. Pest, Szentendre, 17. VI. 1972, G. Ubrizsy; Comit. Bács-Kiskun, Dávod, V. 1975, Z. Sümegi; Comit. Pest, pr. Felsőpakony, 11. VI. 1978, J. Gönczöl; +*Festuca arundinacea* Schreb., Comit. Pest, Vácrátót, 18. VI. 1953, com. J. Podhradszky.

**U. calamagrostidis** (Fuck.) Clint. — *Calamagrostis epigeios* (L.) Roth, Comit. Pest, Gödöllő; 16. IX. 1957, S. Tóth; —, Leányfalu, 31. VII. et 8. IX. 1968, Cs. Dobolyi et S. Tóth, Comit. Somogy, pr. Balatonberény, 23. VI. 1968, S. Tóth et K. Vánky; Comit. Nógrád, Mt. Mátra pr. Salgótarján, 27. V. 1977, J. Gönczöl, S. Tóth, L. Zeller, K. Vánky; Comit. Pest, pr. Felsőpakony, 18. VI. 1978, J. Gönczöl; —, Csévharaszt, 24. VI. 1978, J. Gönczöl; —, Kóspallag, 25. IX. 1979, J. Gönczöl.

**U. carnea** Liro [*U. anomala* J. Kze. var. *carnea* (Liro) Hirschh.] — *Polygonum convolvulus* L.

**U. cordae** Liro ["cordai", *U. anomala* J. Kze. var. *cordae* (Liro) Savile) — *Polygonum hydropiper* L., Comit. Szolnok, pr. Túrkeve, 8. IX. 1979, J. Gönczöl.

**U. crameri** Körn. — *Setaria italica* (L.) PB., Comit. Fejér, pr. Szár, 10. VIII. 1950, J. Bánhegyi; —, Martonvásár, 27. IX. 1956, G. Ubrizsy.

+**U. cynodontis** (P. Henn.) P. Henn. — *Cynodon dactylon* (L.) Pers., Comit. Pest, pr. Szentendre, 27. VII. 1969, G. Ubrizsy.

+**U. davisii** Liro — *Glyceria fluitans* (L.) R. Br., Comit. Hajdú-Bihar, Hortobágy pr. Hortobágyi csárda, 16. VI. 1968, K. Vánky.

[**U. digitariae** (Kze.) Rabh. — *Digitaria sanguinalis* (L.) Scop. = *Ustilago syntherismae* (Schw.) Peck.]

**U. echinata** Schröt. — *Phalaris arundinacea* L.

**U. grandis** Fr. — *Phragmites australis* (Cav.) Trin. et Steudel [*Ph. communis* Trin.], Comit. Pest, Dömsöd, 5. X. 1977, S. Tóth; Comit. Baranya, pr. Sumony, 30. IX. 1954, A. Vass.

+**U. heleochloae** Vánky et Gönczöl — Heleochloa schoenoides (L.) Host, Comit. Pest, pr. Pestlőrinc, 10. X. 1977, J. Gönczöl; Typus; —, 27. VIII. 1979, J. Gönczöl; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 8. XI. 1978, J. Gönczöl

**U. holostei** De Bary — *Holosteum umbellatum* L., Comit. Pest, Hűvösvölgy, 22. IV. 1951, J. Lehoczky; —, Budaörs, 20. IV. 1952, J. Lehoczky.

**U. hordei** (Pers.) Lagerh. — *Hordeum distichon* L., *H. hexastichon* L., *H. vulgare* L., Comit. Pest, Gödöllő, 17. VI. 1964, E. Zahorecz; —, Visegrád, 29. VI. 1968, K. Vánky.

**U. hypodytes** (Schlechtend.) Fr. [*U. spegazzini* Hirschh. var. *agrestis* (H. Syd.) G. W. Fisch. et Hirschh., *U. agrestis* H. Syd., *U. bromi-erecti* Cif.] — *Agropyron intermedium* (Host) PB., Comit. Pest, Mt. Budai-hegység, 8. VII. 1963, S. Tóth et Cs. Dobolyi; —, Gellérthegy, VI. 1964, A. Pénzes; —, Rózsadomb, 28. VI. 1965, G. Ubrizsy; —, pr. Nagykovácsi, 1. VII. 1965, S. Tóth et Cs. Dobolyi; Comit. Fejér, Martonvásár, VII. 1965, J. Podhradszky; *A. repens* (L.) PB., Comit. Pest, Budakalász, 16. VII. 1955, G. Ubrizsy; —, Kőhegy, pr. Pomáz, 19. VI. 1956, J. Podhradszky; Comit. Békés, Szarvas 22. VII. 1959, J. Podhradszky; Comit. Fejér, Martonvásár, 6. VI. 1960, J. Podhradszky; Comit. Szolnok, Karcagtilalmas, 20. VII. 1961, J. Podhradszky; Budapest, VI. 1963, B. Nagy; Comit. Győr-Sopron, Sopronhorpács, VI. 1963, J. Podhradszky; Comit. Pest, Érd, 7. VI. 1964, J. Podhradszky; —, Budakalász, 24. VI. 1964, J. Podhradszky; Comit. Heves, Hatvannagytelek, VI. 1964, E. Szabó; Debrecen, 14. VIII. 1964, O. Tóth; Comit. Pest, Tárnok, 20. IX. 1964, J. Podhradszky; Comit. Pest, pr. Nagykovácsi, 1. VII. 1965, Cs. Dobolyi et S. Tóth; Comit. Heves, mt. Kiseged pr. Eger, 6. VII. 1965, S. Tóth; Comit. Pest, Remetehegy pr. Nagykovácsi, 9. VI. 1975, K. Vánky; Comit. Heves pr. Gyöngyös, 11. VI. 1975, S. Tóth et fam. Vánky; Comit. Pest, Alsópakony, 10. VI. 1976, J. Gönczöl; —, Felsőpakony, 21. V. 1977, J. Gönczöl et K. Vánky; *Agropyron* sp., Comit. Szolnok, Tiszasüly, 16. VI. 1966, G. Ubrizsy; *Bromus tectorum* L., Comit. Pest, Pestlőrinc, 25. V. 1979, J. Gönczöl; +*Stipa capillata* L., Comit. Pest, mt. Nagykevély pr. Budapest, 16. VI. 1963, A. Horánszky; *S. joannis* Čelak. (*S. pennata* L. em. Mansf.), Comit. Pest, pr. Csévharaszt, 18. VI. 1969, G. Ubrizsy; Stipa pulcherrima C. Koch, Comit. Pest, — Mt. Börzsöny, Rigóhegy pr. Nagymaros, 25. IX. 1979, J. Gönczöl et Á. Révay.

+**U. intermedia** Schröt. — *Scabiosa ochroleuca* L., Comit. Fejér. Csákvár, 28. VII. 1966, S. Tóth; Comit. Pest, Ördögtorony pr. Pilisszentiván, 5. X. 1966, S. Tóth.

**U. levis** Magn. — *Avena sativa* L., Comit. Pest, Gödöllő, 26. VI. 1964, E. Zahorecz.

**U. longissima** (Sow. ex Schlechtend.) Meyen — *Glyceria fluitans* (L.) R. Br., Comit. Pest, Pusztaszentjakab pr. Gödöllő, 1. VI. 1974, S. Tóth; *G. maxima* (Hartm·) Holmbg. [*G. aquatica* (L.) Wahlenb.], Comit. Pest, Gödöllő, 22. VIII. 1954, S. Tóth; Comit. Győr-Sopron, Csíkoséger pr. Kapuvár, 6. VI. 1959, M. Komlódi; Comit. Szolnok, pr. Tiszafüred, 23. IX. 1963, S. Tóth et K. Vánky; Comit. Pest, Tólak pr. Pomáz, 11. V. 1964, S. Tóth; Comit. Veszprém, pr. Keszthely, 22. VI. 1968, S. Tóth et K. Vánky; Comit. Hajdú-Bihar, Újszentmargita pr. Egyek, 20. VI. 1974, S. Tóth; Comit. Pest, pr. Kóka, 15. V. 1975, S. Tóth; —, pr. Ócsa 27. VI. 1978, J. Gönczöl, S. Tóth; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 25. VII. 1979, J. Gönczöl et S. Tóth; +*G. nemoralis* (Uechtr.) Uechtr. et Körn., Comit. Veszprém, Balatonudvari, 21. VI. 1968, S. Tóth et K. Vánky; +*G. plicata* (Fr.) Fr., Comit. Zala, Szentliszló, 5. VII. 1978, J. Gönczöl.

**U. major** Schröt. — *Silene borysthenica* (Grun.) Walt. [*S. parviflora* Pers.], Comit. Pest, Gödöllő, 27. VI. 1968, S. Tóth et K. Vánky; Comit. Bács-Kiskun, pr. Fülöpháza, 26. VI. 1979, S. Tóth et J. Gönczöl; *S. otites* (L.) Wibel, Comit. Pest, Kisszénás pr. Pilisszentiván, 17. V. 1967, A. Horánszky; Comit. Baranya, pr. Pécs, 24. VI. 1968, S. Tóth et K. Vánky; Comit. Pest, pr. Veresegyház, 18. VIII. 1969, S. Tóth; —, Gödöllő, Kastélypark, 22. VI. 1970 et 6. VII. 1974, S. Tóth; —, Várhegy pr. Csővár, 14. VIII. 1973, S. Tóth; Comit. Somogy, pr. Középrigóc, 14. VI. 1976, A. Vass et S. Tóth.

**U. maydis** (DC.) Corda [*U. mays-zeae* (DC.) P. Magn.] — *Zea mays* L., Comit. Fejér, Martonvásár, V. 1959, J. Podhradszky.

**U. muricata** (Ces.) Liro [*U. anomala* J. Kze var. *muricata* (Liro) B. Lindeb.] — *Polygonum mite* Schrank, Comit. Pest, pr. Dabas, 12. X. 1978 et 26. VI. 1979, J. Gönczöl; *P. persicaria* L., Comit. Pest, Csepel sziget, pr. Makád, 24. IX. 1971, Z. Toborffy.

**U. neglecta** Niessl [*U. panici-glauci* Wint.] — *Setaria glauca* (L.) P. B. [*S. lutescens* (Stuntz) F. C. Hubb.] Comit. Heves, mt. Répástető, pr. Eger, 19. X. 1951, S. Tóth; —, Mt. Bükk pr. Felsőtárkány, 15. X. 1953, S. Tóth; Comit. Pest, Mt. Budai-hegység, mt. Nagykevély, 2. X. 1955, A. Horánszky; —, Gödöllő, IX. 1965, E. Zahorecz; —, Babatpuszta pr. Máriabesnyő, 6. IX. 1966, S. Tóth et Cs. Dobolyi; Comit. Veszprém, pr. Úrkút, 11. IX. 1968, S. Tóth; —, pr. Balatonakarattya, 24. X. 1970, G. Ubrizsy, sub *Ustilago crameri*; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 20. IX. 1979, Á. Révay et J. Gönczöl; *S. viridis* (L.) P. B., Debrecen, X. 1976, L. Varga, sub *U. crameri*.

+**U. nigra** Tapke — *Hordeum* spp. (Podhradszky 1966: 167).

**U. nuda** (Jens.) Rostr. — *Hordeum distichon* L., Comit. Pest, pr. Nagykovácsi, 1. VII. 1965, S. Tóth et Cs. Dobolyi; *H. vulgare* L.

**U. ornithogali** (Schm. et Kze.) P. Magn. — *Gagea villosa* (M. B.) Duby [*G. arvensis* (Pers.) Dum.]

**U. oxalidis** Ellis et Tracy — *Oxalis fontana* Bunge, Comit. Pest, Gödöllő, 20. VIII. 1965, 8. VII. 1971 et 15. VIII. 1975, S. Tóth; Comit. Vas, pr. Szőce, 14. IX. 1966, S. Tóth; —, pr. Szentgotthárd, 15. IX. 1966, S. Tóth; —, Szombathely, 16. IX. 1966, S. Tóth; Comit. Veszprém, pr. Bakonybél, 19. IX. 1979, S. Tóth.

**U. reticulata** Liro — *Polygonum lapathifolium* L., Comit. Baranya, Sellye, 21. IX. 1959, Ö. Szatala; Comit. Pest, Gödöllő, 24. IX. 1965, E. Zahorecz; Comit. Somogy, Balatonberény, 23. VI. 1968, S. Tóth et K. Vánky; Comit. Veszprém, Hétházpuszta pr. Várpalota, 29. VIII. 1975, S. Tóth; Comit. Zala pr. Szentliszló, 28. IX. 1978, J. Gönczöl; Comit. Bács-Kiskun, Tőserdő pr. Lakitelek, 20. IX. 1979, Á. Révay et J. Gönczöl; *P. ? persicaria* L.

+**U. scabiosae** (Sow.) Wint. — *Knautia arvensis* (L.) Coult., Comit. Pest, Gödöllő, 24. VI. 1973, 12. V.–26. VI. 1974, S. Tóth; Comit. Vas, mt. Hercseghegy pr. Kissitke, 18. VII., 1977, S. Tóth; —, pr. Kissomlyó, 3. X. 1977, S. Tóth; Comit. Pest, Rákoskeresztúr 8. VI. 1978, S. Tóth.

**U. scorzonerae** (Alb. et Schw.) Schröt. — *Podospermum canum* C. A. Mey., *Scorzonera hispanica* L., *S. humilis* L., *S. purpurea* L.

+**U. serpens** (Karst.) B. Lindeb. [*U. aculeata* (Ule) Liro] — *Agropyron repens* (L.) PB., Comit. Szolnok, pr. Tiszafüred, 29. VI. 1978, T. et K. Vánky.

**U. spermophora** Berk. et Curt. [*Sphacelotheca spermophora* (Berk. et Curt.) Moesz] — *Eragrostis megastachya* (Koel.) Lk., *E. minor* Host [*E. poaeoides* PB].

**U. striiformis** (Westend.) Niessl [*U. brizae* Ule, *U. bromina* H. Syd., *U. poarum* Mc Alp., *U. salveii* Berk. et Br., etc.] — +*Arrhenatherum elatius* (L.) J. et K. Presl, Comit. Pest, Remetehegy pr. Nagykovácsi, 9. VI. 1975, S. Tóth et fam. Vánky; Comit. Veszprém, Mt. Bakony pr. Hármaskút, 30. IX. 1975, S. Tóth; +*Briza media* L., Comit. Fejér, pr. Csákvár, 24. VI. 1965, S. Tóth; *Bromus inermis* Leyss.; *Dactylis glomerata* L., Comit. Pest, Gödöllő, 30. X. 1963, E. Zahorecz; —, mt. Kopasz-oldal pr. Nagykovácsi, 1. VII. 1965, S. Tóth; Comit. Baranya, Dömörkapu pr. Pécs, 29. VI. 1966, A. Vass et S. Tóth; mt. János-hegy, Budapest, 20. VI. 1968, K. Vánky; +*D. polygama* Horv. [*D. aschersoniana* Graebn.], Comit. Heves, Mátraháza, 20. V. 1964, J. Podhradszky; +*Holcus lanatus* L., Comit. Veszprém, Mt. Bakony, pr. Bakonyszentlászló, 19. VII. 1966, Cs. Dobolyi; +*Poa palustris* L., pr. János-hegy, Budapest, 20. VI. 1968, K. Vánky.

**U. syntherismae** (Schw.) Peck [*U. rabenhorstiana* Kühn] — *Digitaria sanguinalis* (L.) Scop., Debrecen, Nagyerdő, 1. VIII. 1953, G. Ubrizsy; Budapest, Pestlőrinc, 20. VIII. 1974, 20. VII. 1975, J. Gönczöl; Comit. Pest, Gödöllő, 15. VIII. 1975, S. Tóth et G. Turcsányi; —, pr. Alsópakony, 6. X. 1977, J. Gönczöl; —, pr. Felsőpakony, 12. X. 1977, J. Gönczöl; —, Pestimre, 15. et 30. X. 1977, J. Gönczöl.

**U. tragopogonis-pratensis** (Pers.) Rouss. — *Tragopogon orientalis* L., Comit. Zala, pr. Bucsuszentlászló, 23. V. 1954, Á. KÁROLYI; pr. Budapest, 4. VI. 1981, S. TÓTH.

+**U. trichophora** (Link) Kze. [*U. crus-galli* Tracy et Earle, *U. globigena* Speg., *U. sphaerogena* Burrill] — *Echinochloa crus-galli* (L.) PB., Comit. Békés, Ecsegfalva, 2. X. 1962, A. KACSÓ; Comit. Somogy, Somogyvár, 1965, Z. ANGYAL; Comit. Hajdú-Bihar, pr. Debrecen, 13. X. 1970, T. HALÁSZ; Comit. Szolnok, pr. Kisújszállás, 23. IX. 1977, S. TÓTH; —, pr. Túrkeve, 8. IX. 1979, J. GÖNCZÖL; Comit. Bács-Kiskun, Tőserdő, pr. Lakitelek, 20. IX. 1979, Á. RÉVAY et J. GÖNCZÖL.

**U. tritici** (Pers.) Rostr. — *Triticum aestivum* L. em. Fiori et Paol. [*T. vulgare* Vill.], very common.

**U. vaillantii** Tul. (*U. scillae* Cif.) — *Muscari comosum* (L.) Mill., Comit. Pest, mt. Naszály pr. Vác, 27. V. 1950, G. UBRIZSY; —, Várhegy, Visegrád, 25. V. 1962, A. HORÁNSZKY; Comit. Komárom, Tatabánya, Turul, 2. VI. 1964, S. TÓTH; Comit. Pest, Kálváriadomb pr. Galgahévíz, 25. V. 1972, S. TÓTH; *Scilla bifolia* L., Comit. Pest, Csepel-sziget, pr. Makád, 6. IV. 1965, S. TÓTH; Comit. Fejér, pr. Adony, 3. IV. 1968, S. TÓTH.

**U. vavilovii** Jacz. [=? *U. tritici* (Pers.) Rostr.] — *Secale cereale* L., Comit. Borsod-Abaúj-Zemplén, pr. Végardó, 5. VII. 1956, G. UBRIZSY.

**U. violacea** (Pers. ex Pers.) Rouss. [*U. antherarum* Fr., *U. dianthorum* Liro, *U. lychnidis-dioicae* Liro, *U. silenes-inflatae* Liro, etc.] — +*Dianthus pontederae* Kern., Comit. Veszprém, pr. Uzsa, 22. VI. 1968, S. TÓTH et K. VÁNKY; —, pr. Balatonberény, 22. VI. 1968, S. TÓTH et K. VÁNKY; Comit. Pest, Kálváriadomb pr. Galgahévíz, 25. V. 1972, S. TÓTH; Comit. Veszprém, pr. Tihany, 30. V. 1977, J. GÖNCZÖL, S. TÓTH, L. ZELLER, K. VÁNKY; Comit. Csongrád, Ásotthalom, 1. VI. 1979, S. TÓTH et E. TÓTH; +*D. serotinus* W. et K., Comit. Fejér, pr. Csákvár, 15. VI. 1978, J. GÖNCZÖL et S. TÓTH; —, pr. Csákberény, 29. VI. 1979, S. TÓTH; *Saponaria officinalis* L., Comit. Pest, pr. Isaszeg, 6. VII. 1955 et 9. VII. 1976, S. TÓTH; Debrecen, 15. VI. 1968, K. VÁNKY; Comit. Pest, mt. Fóti Somlyó pr. Fót 30. VII. 1970, S. TÓTH; —, Haraszti-erdő pr. Gödöllő, 21. VIII. 1976, S. TÓTH; *Silene alba* (Mill.) E. H. L. Krause [*Melandrium album* (Mill.) Garcke], Comit. Zala, Gellénháza, 24. VI. 1953, Á. KÁROLYI; Comit. Pest, Gödöllő, 1. VI. 1968, S. TÓTH; —, 27. VI. 1968, S. TÓTH et K. VÁNKY; Comit. Veszprém, pr. Uzsa, 22. VI. 1968, S. TÓTH et K. VÁNKY; Comit. Szolnok, pr. Tiszafüred, 18. V. 1972, S. TÓTH; Budapest, Aquincum, 1. V. 1976, K. VÁNKY; Comit. Baranya, Mélyvölgy pr. Komló, 19. V. 1977, A. VASS et K. VÁNKY; Comit. Nógrád, pr. Bárna, 21. V. 1977, S. TÓTH; Comit. Pest. pr. Felsőpakony, 21. V. 1977, J. GÖNCZÖL et K. VÁNKY; Comit. Szolnok, pr. Tiszafüred, 29. VI. 1978, T. et K. VÁNKY; Comit. Pest, pr. Galgahévíz, 29. VII. 1978, S. TÓTH; *S. bupleuroides* L. [*S. longiflora* Ehrh.] +*Silene vulgaris* (Moench) Garcke [*S. inflata* (Salisb.) Sm., *S. cucubalus* Wib.], Comit. Veszprém, Mt. Bakony, pr. Bakonybél, 26. VI. 1963, S. TÓTH; Comit. Somogy, Balatonberény, S. TÓTH et K. VÁNKY; Comit. Pest, Ócsa, 22. VI. 1978, J. GÖNCZÖL et S. TÓTH.

+**U. violacea** (Pers.) Rouss. var. **stellariae** (Sow.) Savile [*U. stellariae* (Sow.) Liro] — *Myosoton aquaticum* (L.) Moench [*Stellaria aquatica* (L.) Scop.], Comit. Pest, pr. Ócsa, 27. VIII. 1950, G. UBRIZSY; —, 9. VI. 1962, V. CSAPODY; —, 19. VI. 1978, J. GÖNCZÖL; *Stellaria graminea* L., Comit. Borsod, Mt. Bükk, pr. Ómassa, 23. VII. 1979, S. TÓTH.

! **U. abstrusa** Malençon — *Juncus gerardii* Loisel. (golden yellow powder in the seeds).

! **U. albida** Bubák — *Genista* sp. (white spore-mass in the anthers).

! **U. avicularis** Liro — *Polygonum aviculare* L. (light brown spore-mass in the flowers).

! **U. cardui** Fisch. v. Waldh. — *Carduus nutans* L. (brownish-violet, powdery spore-mass in the heads).

! **U. carnea** Liro — *Fallopia convolvulus* (L.) A. Löve [*Polygonum convolvulus* L.] (in the swollen flowers).
! **U. ceparum** Glow. — *Allium cepa* L. (on the leaves and bulbs).
! **U. cichorii** H. Syd. — *Cichorium intybus* L. (destroying the inflorescence).
! **U. corcontica** (Bub.) Liro — *Calamagrostis canescens* (Web.) Roth em. Druce, *C. stricta* (Timm.) Koel. (long streaks on the leaves and stems).
! **U. ducellieri** R. Maire — *Arenaria serpyllifolia* L. (brown-violet spore-mass in the seeds).
! **U. duriaeana** Tul. — *Cerastium* spp. (in the seeds).
! **U. elytrigiae** Golov. — *Agropyron repens* (L.) PB. (in the ovaries).
! **U. flosculorum** (D.C.) Fr. — *Knautia arvensis* (L.) Coult. (dark brownish-violet, powdery spore-mass in the anthers).
! **U. goeppertiana** Schröt. — *Rumex acetosa* L., *R. thyrsiflorus* Fingerh. (brown-violet, swollen areas on the leaves).
! **U. haynaldiae** Becerescu — *Dasypyrum villosum* (L.) Borb. [*Haynaldia villosa* (L.) Schur] (destroying the spikelets).
! **U. heufleri** Fuck. — *Tulipa sylvestris* L., *T.* spp., *Erythronium* spp. (black pustules on the leaves).
! **U. kuehneana** Wolff — *Rumex acetosa* L., *R. acetosella* L. (on the leaves and stems as pustules, in the inflorescence as brown-violet, dusty spore-mass).
! **U. lolii** P. Magn. — *Lolium temulentum* L. (in the spikelets).
! **U. luzulae** Sacc. — *Luzula* spp., see: *Cintractia luzulae*; *L. campestris* (L.) D.C., *L. forsteri* (Sm.) D.C., *L. luzulina* (Vill.) DT. et S., *L. luzuloides* (Lam.) Dandy et Wilm., *L. multiflora* (Ehrh. ex Retz.) Lej. (black, at first hard, later more or less powdery spore-mass in the flowers).
! **U. marginalis** (D.C.) Lév. — *Polygonum bistorta* L. (brown margin on the leaves).
! **U. minima** Arthur — *Stipa* spp., *Oryzopsis* sp., *Agropyron repens* (L.) PB. (surrounding the slightly swollen internodes).
! **U. moenchiae-manticae** Lindtner — *Moenchia mantica* (L.) Bartl. (brown-violet, powdery spore-mass in the seeds).
! **U. nagornyi** Uljanish. — *Pholiurus pannonicus* (Host) Trin. (in the flowers).
! **U. nannfeldtii** Liro — *Gentiana* sp. (brown-violet, powdery spore-mass in the seeds).
! **U. nebrodensis** Frag. — *Melica ciliata* L. (in the inflorescence).
! **U. parlatorei** Fisch. v. Waldh. — *Rumex* spp. (dark violet, powdery pustules on the stems, leaves and flowers).
! **U. passerini** Fisch. v. Waldh. — *Aegilops cylindrica* Host (in the flowers).
! **U. pinguiculae** Rostr. — *Pinguicula alpina* L., *P. vulgaris* L. (in the anthers).
! **U. pustulata** (D.C.) Wint. — *Polygonum bistorta* L. (brown-violet pustules on the leaves).
! **U. rhynchosporae** Saut. ap. Rabenh. — *Rhynchospora alba* (L.) Vahl (black, powdery spore-mass in the inflorescence).
! **U. salviae** (Ferr.) Cif. — *Salvia pratensis* L. (pale violet spore-mass in the anthers).
! **U. stygia** Liro — *Rumex acetosa* L. (brownish-violet, powdery spore-mass in the inflorescence).
! **U. succisae** P. Magn. — *Succisa pratensis* Moench (white or cream-coloured spore-mass in the anthers).
! **U. thlaspeos** (G. Beck) Lagerh. ap. Syd. — *Arabis alpina* L., *A. hirsuta* (L.) Scop., *Cardaminopsis petraea* (L.) Hilt., *Draba* sp., *Thlaspi* sp. (light brown powdery spore-mass in the seeds).
! **U. trebouxii** H. et P. Syd. — *Agropyron repens* (L.) PB., *Melica ciliata* L. (streaks on the leaves).
! **U. ustilaginea** (D.C.) Liro — *Polygonum bistorta* L. (in the flowers).
! **U. vuijckii** Oudem. et Beijer. — *Luzula* spp. (ochre, powdery spore-mass in the seeds).

! **U. warmingii** Rostr. — *Rumex aquaticus* L., *R. crispus* L., *R. obtusifolius* L., *R.* spp. (in the flowers and in deformed leaves, mainly marginal).

! **U. williamsii** (Griff.) G. W. Fisch. et Hirschh. — *Stipa* spp. (on the culms).

## **Ustilentyloma** Savile

Sori and spores resembling *Entyloma* but spore germination of *Ustilago* type.

! **Ue. fluitans** (Liro) Vánky — *Glyceria fluitans* (L.) R. Br., *G. plicata* (Fr.) Fr. (first yellowish, later light brown spots or streaks on the leaves).

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# DIFFERENTIATION AND PRODUCTION OF CANNABINOIDS IN TISSUE CULTURES OF *CANNABIS SATIVA*

G. VERZÁR-PETRI, T. LADOCSY and P. OROSZLÁN

DEPARTMENT OF PHARMACOGNOSY, SEMMELWEIS MEDICAL UNIVERSITY, BUDAPEST, HUNGARY

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Authors prepared callus tissue cultures of a textile hemp sort called "Kompolti". It was found to grow better on MURASHIGE–SKOOG agar than on MILLER medium. Differentiated plants were produced from seeds and leaves, on which flowering could be induced by gibberellin. The anatomical characteristics of the non-differentiated and differentiated cultures are described. By gas-chromatographic and TLC examinations it was verified that the THC content can be demonstrated only in differentiated plants. In the callus which is not differentiated externally, but shows initial differentiation, only cannabinoid-like precursor compounds can be found.

## Introduction

In the different sorts of *Cannabis sativa* plant psychotropic secondary plant compounds. so-called cannabinoids, which are characteristic of the hemp are present in varying quantities and compositions (MECHOULAM 1973). But in this case not only the regional sorts show a special, characteristic cannabinoid-composition, but the qualitative and quantitative distribution of these compounds is also typical of the organs of single plant-individuals (TURNER 1977, VERZÁR-PETRI et al. 1980, 1981).

Plant tissue culturing is a good method by observation of plant metabolism but unfortunately the secondary metabolism in cultures differs mostly from that in intact plants and the mass of metabolites in the callus is less than in the intact plant organs (STABA 1977).

According to earlier publications, the secondary plant metabolism is in correlation with callus differentiation in other plants (PETERS et al. 1974, TABATA et al. 1971).

HEMPHILL and collaborators (1978) found that tissue cultures originating from different parts of the hemp lost not only their capacity of organisation, but their cannabinoid production stopped, too, as opposed to callus originating from other plants. For instance, tobacco preserves its capacity of organisation (PETERS et al. 1974) and is able to produce secondary metobolites characteristic of the intact plant. HEMPHILL and collaborators attribute the circumstance that tissue cultures of hemp are unable either of organisation or of forming cannabinoids to the presence of synthetic auxin (2,4-D).

## Methods

Authors used callus cultures originating from leaves of the Hungarian sort "Kompolti" (Fig. 1, ABC), poor in THC and individuals originating from seeds grown in sterile conditions. The tissues were cultivated either on modified MURASHIGE–SKOOG nutrient medium or on

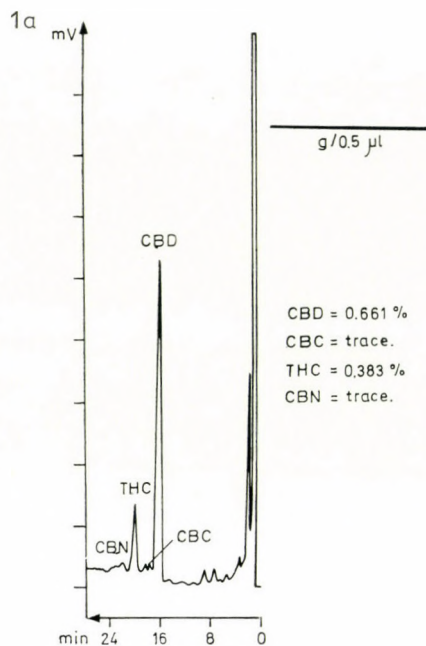
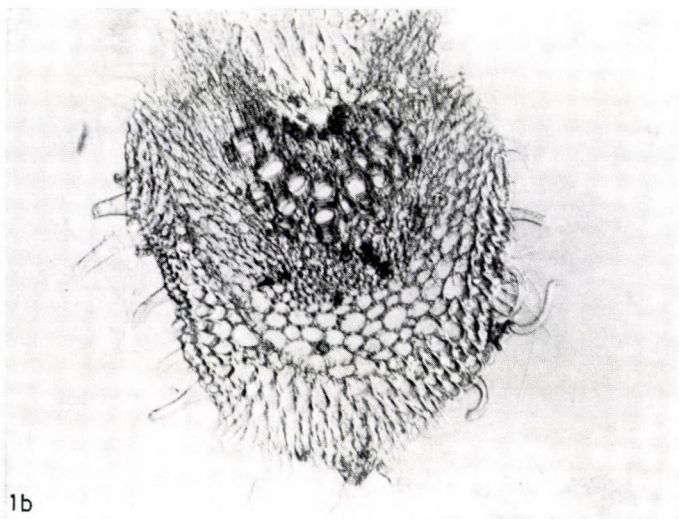
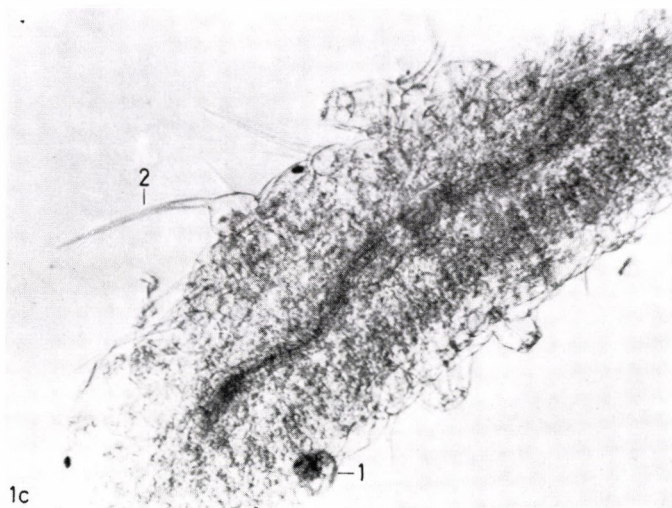



*Fig. 1.* A: Gas chromatogram (GC) of the intact leaf of the "Kompolt" hemp-sort. B: Cross-section of the main rib. C: Cross-section of the side part of the leaf 1 = glandular hair, 2 = covering trichome

MILLER's basic medium (1968), which contains anorganic salts, vitamines, and saccharides as carbonium sources as well as some growth stimulating hormones. The cultures were cultivated at 26 °C both in dark and in light.

The fresh weight of the cultures was measured, they were lyophylised, and subsequently extracted with chloroform. The extracts were evaporated and the dry remnants solved again in alcohol for gas chromatographic analysis, which was made on a Chrom 5 apparatus. The chromatographic parameters were as follows: carrier gas was $N_2$ 40 ml/min, the detector was a $H_2$ flammionizations type, the temperature programme was 2 °C/min from 200 °C to 255 °C. The injector temperature was 265 °C; detector temperature 300 °C. Size of column: 3 m long and 3 mm in diameter, its material was glass. The stuffing was a tandem (mixed) packing-material, containing 3% SE-30 and 3% $OV_{17}$ on Chromosorb W adsorbent with 100–120 meshes.

Thin layer chromatography was developed on ready-made silica gel HF 254 Merck plates. Developing system was: Hexane-Dyoxane 4 : 1. Spraying reagent was Echt Blue Salt-B solved in 70% ethanol.

## Results and discussion

1. The seeds previously sterilised with 20% Na hypochloride and washed in sterile water were germinated on MURASHIGE–SKOOG nutrient medium (using 1 mg/l indole acetic acid and 1 mg/l kinetine). The seeds developed to seedlings similarly to the intact plant. Later on they produced foliage leaves, too, which were either simple ones or composed of 2–3 leaflets. In the same plants we could detect cannabinoids.

By modification of the nutrient medium (using 2 mg/l gibberelline), plants flowering several times could be brought up, which were male and female plants but they did not produce seeds (Fig. 2). The plantlet growing

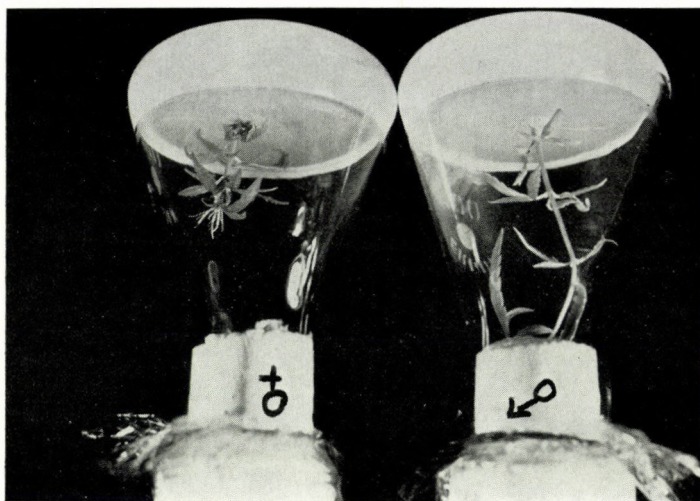



*Fig. 2.* Gibberelline influenced plantlet in sterile condition grown without hormones

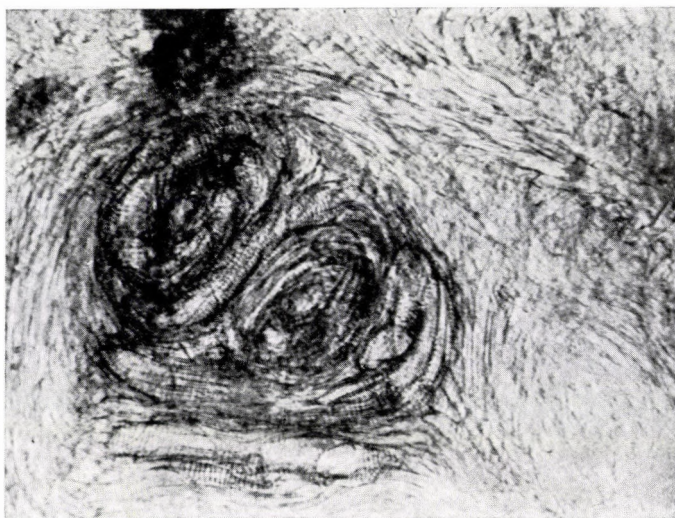



*Fig. 3.* Weakly developed vascular system in leaf of the plant grown on basic nutrient medium containing gibberellic acid

*Fig. 4.* Leaf epidermis differentiation in the same plantlet

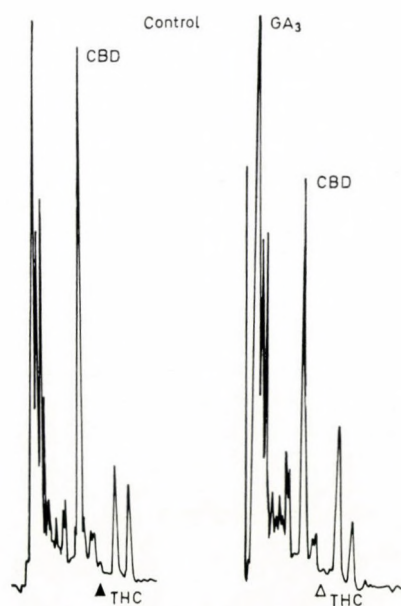



*Fig. 5.* Cannabinoid-content formation influenced by gibberellic acid (GC)

in the glass colb was 1000 times smaller than plants growing on open soil. The primary vessels (the transfer system), the basic tissue and the epidermic system developed, and stomata and trichomes organized (Figs 3, 4). However, their size and quantity was strongly diminished. In these plantlets we could detect cannabinoids but in smaller amounts than in the intact plant (Fig. 5).

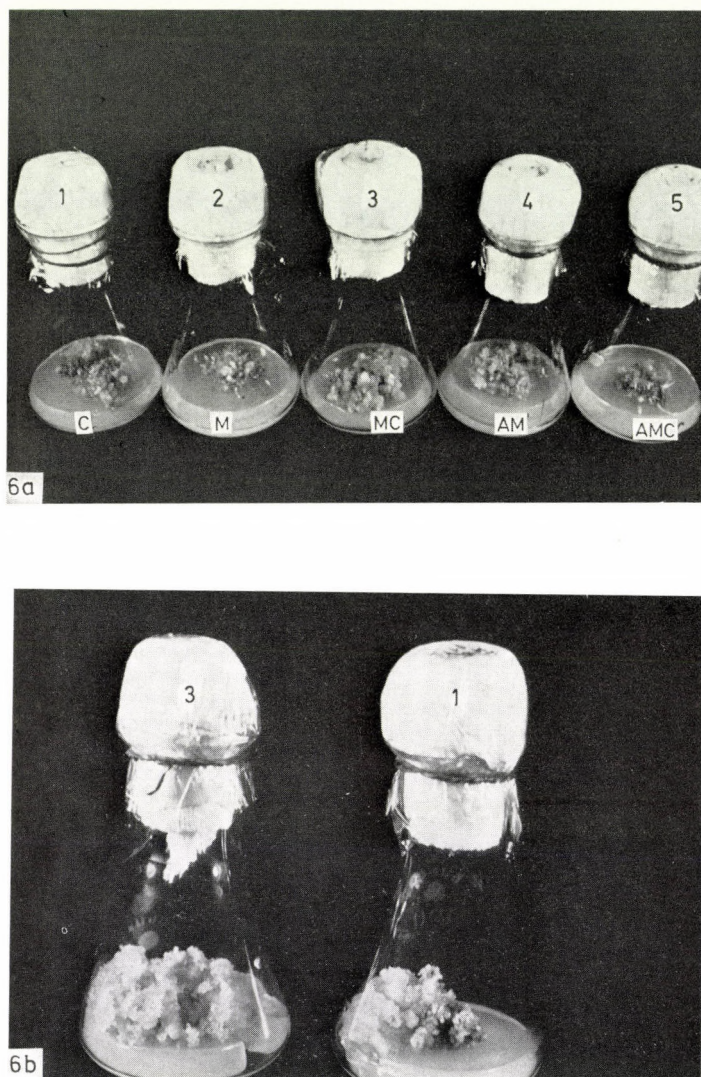



*Fig. 6.* A: Callus cultures grown on different nutrient media. 1. MURASHIGE–SKOOG medium 1-month-old callus, hormone concentration-like the 3rd container (see Table 1). 2. MILLER medium; 2-months-old culture, hormone concentration 2,4-D, 1 mg/l. 3. MILLER medium, hormone conc., see Table 1. 4. MILLER medium, hormone conc., kaseine, 2 mg/l. 5. MILLER medium, hormone conc., see Table 1 + 2 mg/l kaseine. B: 1 and 3 after more passage

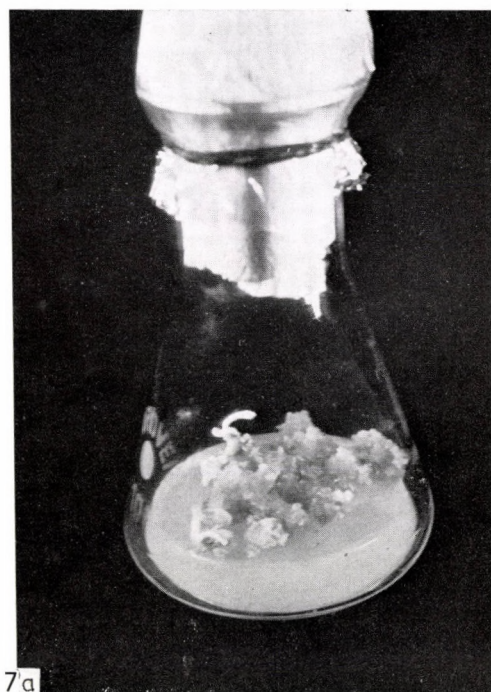



*Fig. 7.* A: Sprout organisation on Miller medium. B: Total plantlet with sprout and root

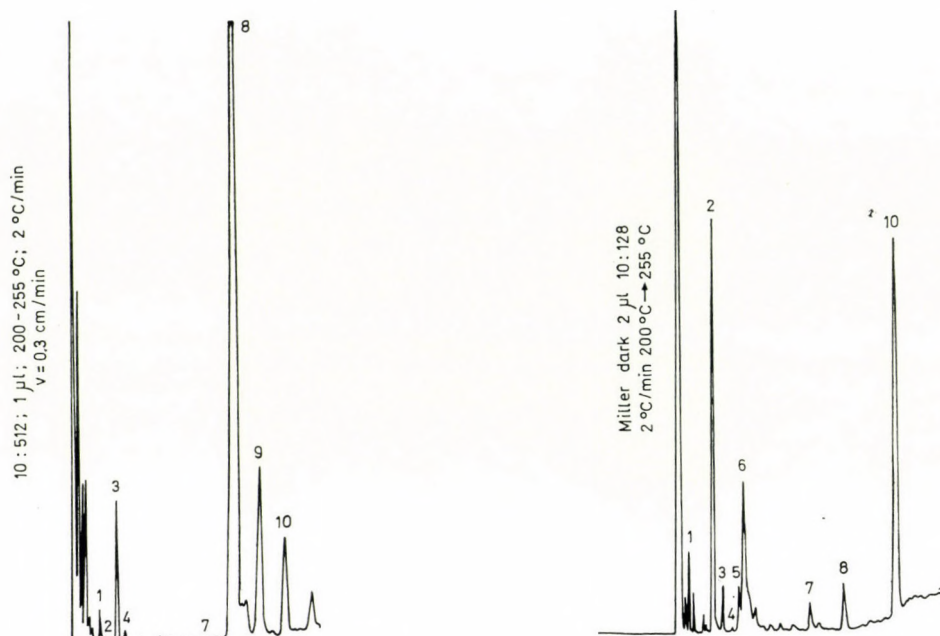



*Fig. 8.* GC from callus culture with cannabinoid-like compounds, A: in light, B: in dark

2. In case of using the tissue-induction method originated from the leaves of hemp the growing effect was better in the earlier period on MURASHIGE–SKOOG nutrient medium (5–6 g during 6 weeks), while the fresh weight increment of one-year-old tissue cultures was higher on nutrient media according to MILLER (7–8 g in 6 weeks) (Figs 6A, B).

On MURASHIGE-SKOOG medium neither roots nor shoots are organized, while on the MILLER medium sporadic root organisation was observed, and twice also degenerated shoot organisation was detected (Figs 7A, B). The hormone concentration was the same on both media (indole acetic acid 1 mg/l, nicotinic acetic amide 0.1 mg/l, 2,4-D 0.2 mg/l, and KIN 2 mg/l) which was equal to the concentration of medium No. 4 according to HEMPHILL.

In the tissue cultures grown on the two basic media no cannabinoids were found, however unknown components were detected with the same retention time. These components grown on the two different nutrient media differed in number and quantity. On the M-S medium these unknown components appeared in smaller amounts. In illuminated cultures on M-S medium the unknown components quantitatively increased with the exception of components 5 and 6 (Table 1).

On MILLER's basic nutrient medium adding to it more indole acetic acid (IAA 90.02 mg/l), retaining the same NAA-, and 2,4-D hormone-con-

**Table 1**

*Retention time and relative quantity of unknown metabolites isolated from Cannabis callus*

| Callus sample No. | IAA, mg/l | KIN, mg/l | Fresh weight, g/45 days | Unknown compounds and their retention times | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 (224) | 2 (270) | 3 (346) | 4 (406) | 5 (460) | 6 (486) | 7 (1000) | CBD (1112) | $^{9}$-THC (1280) | 8 (1280) | 9 (1382) | CBG (1436) | 10 (1661) |
| 1 | 0.02 | — | 5.060 | + | + | ++ | (+) | — | — | ((+)) | — | — | ++ ! | + | — | + |
| 2 | | 0.001 | 4.025 | + | ((+)) | + | (+) | — | — | ((+)) | — | — | + ! | + | — | (+) |
| 3 | | 0.010 | 4.416 | ++ | ((+)) | +++ | + | — | — | ((+)) | — | — | +++ ! | +++ | — | ++ |
| 4 | | 0.100 | 6.749 | (+) | — | (+) | (+) | — | — | ((+)) | — | — | + ! | +++ | — | + |
| 5 | | 1.000 | 4.411 | + | ((+)) | (+) | (+) | — | — | ((+)) | — | — | + ! | + | — | (+) |
| 6 | | 2.000 | 3.271 | +++ | (+) | (+) | + | — | — | ((+)) | — | — | + ! | (+) | — | (+) |
| M-S dsrk | 1.00 | 2.000 | 6.326 | ((+)) | + | ((+)) | — | + | ++ | +++ | + | + | ((+)) | — | — | (+) |
| M-S light | | 2.000 | 5.486 | ((+)) | ++ | ((+)) | — | + | + | ((+)) | — | — | ((+)) | — | — | + |
| Miller dark | | 2.000 | 7.826 | ((+)) | +++ | (+) | (+) | + | +++ | (+) | — | — | + | — | — | +++ ! |
| +M-S dark | 0.02 | 2.000 | 5.548 | ((+)) | ++ | +++ | — | — | — | ((+)) | — | — | + | — | | + |
| +M-S dark diff. | | | 7.310 | ((+)) | ++ | +++ | — | — | — | ((+)) | — | — | + | — | | + |

Hormone concentration in all cultures (expect those marked by star): NAA 0.1 mg/l; 2.4-D 0.2 mg/l.

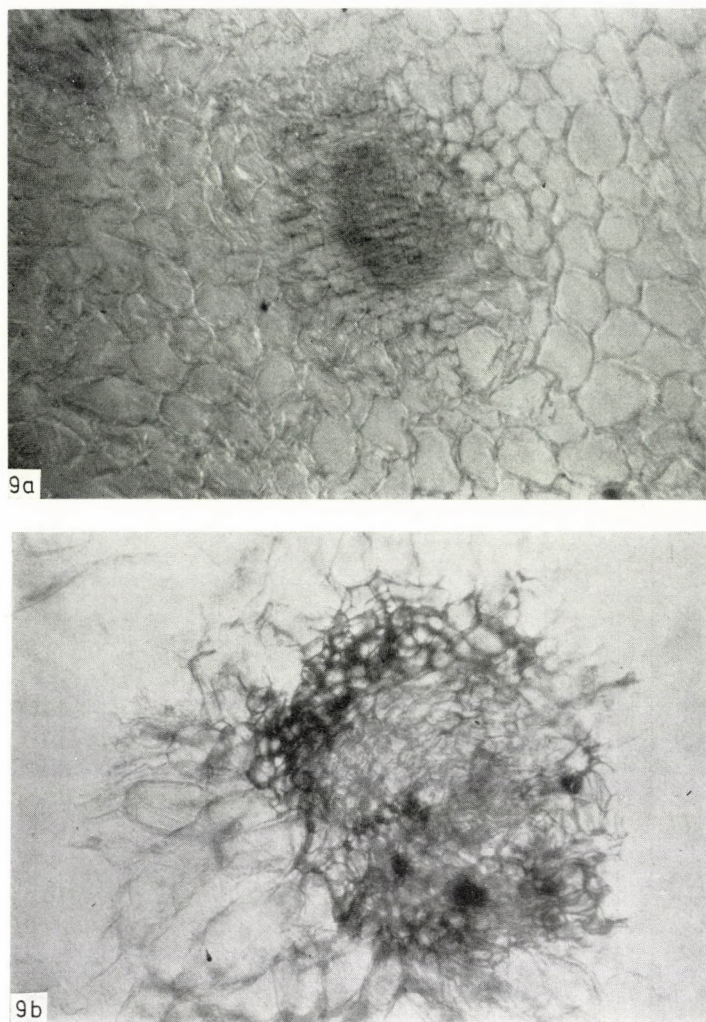



*Fig. 9.* Inner differentiation in the plantlet grown on MILLER medium. a: cross-section of root-like organ, b: cross-section of sprout-like organ

centration, but varying the KIN concentration, we could detect a difference in the growth of fresh weight and in the number and amount of the unknown components (Fig. 8). Components 7, 8 and 9 had the same retention time on GC as the cannabinoids. The $R_t$ of component 8 was equal to the $R_t$ of $\Delta^9$ THC in the range of the mentioned chromatographic parameters. This component was present in all samples and was the main component in samples 1 to 6.

In these undifferentiated tissue cultures we could find differentiation processes as well as the transfer system and little trichomes (Figs 9–11).

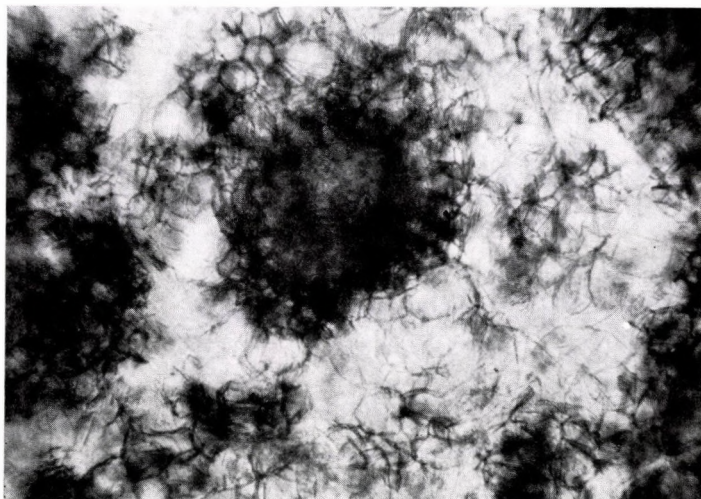



*Fig. 10.* Inner structure of non-differentiated callus culture. 1 = vascular system

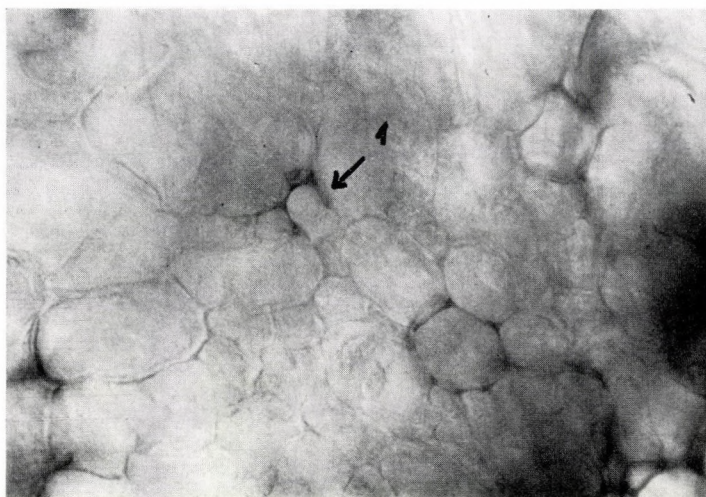



*Fig. 11.* Inner structure of non-differentiated callus culture. 1 = secreting cells

## Summary

1. In contrast with published data, tissue cultures of hemp are capable of differentiation.

2. They are able to synthetize cannabinoid-like compounds.

3. Taking into consideration these findings the genetic and chemosystematic selection of hemp by application of tissue cultures might be possible.

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CONTENTS

ACTA BOTANICA

## КСИЛОТОМИЧЕСКИЕ ИССЛЕДОВАНИЯ НЕКОТОРЫХ ВЕНЕСУЭЛЬСКИХ ВИДОВ

К. БАБОШ, И. Р. БЕРМУДЕЗ, Л. Й. Ц. КУМАНА

Авторы обсуждают внешнюю морфологию следующих четырех видов ***Capparis***, из, их экологическую характеристику, условия прорастания и основные анатомические свойства: ***Capparis sessilis*** **Banks ex DC.**, ***C. pachaca*** **H. B. et K.**, ***C. odoratissima*** **Jacq.**, ***C. stenosepala*** **Urb.**

## ВОСТОЧНО-АФРИКАНСКИЕ МХИ BRYOPHYTES

М. БИЗО, Т. ПОЧ

В статье описываются новые местанахождения 217 видов мхов собранных Поч и сотрудниками в Восточной Африке, в основном в Танганьике, их распространение и таксономические примечания. Для Восточной Африки оказались новыми 11 видов, 3 вида для всей тропической Африки и 14 видов для Африканского континента. Следующие комбинации новые: ***Jonesiobryum sphaerocarpum*** **(Biz.) Biz. et Pócs**, ***Squamidium biforme*** **(Hpe) Broth. var.** ***densirameum*** **(Broth) Biz.**, ***Lopidium struthoipteris*** **(Brid.) Fleisch. var.** ***campenonii*** **(Ren. et Card.) Biz.**, Новая разновидность ***Papillaria africana*** **(C. Müll.) Jaeg. var.** ***flagellifera*** **Bizot**, тогда как ***Fabronia bizotii*** **Pócs**, ***F. pocsii*** **Bizot var.** ***cameruniae*** **Bizot** получил новое название, как новый самостоятельный вид.

Статью дополняет ключ для определения африканских *Schoenobryum*, карта распространения 13 видов а также фотографии местонахождения мхов.

## ИЗУЧЕНИЕ ТРИБЫ *RONDELETIEAE* (RUBIACEAE) III РОДЫ *ROGIERA* И *ARACHNOTHRYX*

А. БОРХИДИ

На основании сравнительных исследований северно-американских видов рода ***Rondeletia*** автор нашел основные родовые различия между Средне-Американскими и Антильскими видами. Автор считает необходимым для Средне-американских видов обновить описание родов ***Rogiera*** **Planch.** и ***Arachnothryx*** **Planch.**, а также описывает соответственные новые комбинации.

## КАМБИАЛЬНАЯ АКТИВНОСТЬ В *MANGIFERA INDICA* L.

И. С. ДЕЙВ, К. С. РАО

Авторы изучали камбиальную активность *M. indica* L. с января до декабря 1978 года, на протяжении целого года. Камбий состоящий из фузиформных и инициальных клеток является не слоистой тканью. Радиальное утолщение ствола непрерывно на протяжении целого года, т. е. камбий в каждом месяце активен. Несмотря на это, более сильную камбиальную активность, можно наблюдать во второй половине года. По танген-

циальному направлению камбий образовывает васкулярные элементы. У фузиформных инициальных клеток длина и ширина различна в отдельных месяцах и это показывает тесную связь в изменении длины ксилемных волокон. Климатические факторы не оказывают никакого влияния на активность камбия.

## КУБИНСКИЕ *RUBIACEAE*, II—III
## II РОД *CASASIA* A. RICH. В КУБЕ
## III НОВЫЕ ДАННЫЕ В РОДЕ *ANTIRHEA* COMMERS

М. ФЕРНАНДЕЗ ЗЕКУЕЙРА, А. БОРХИДИ

Авторы статьи описали новый вид **Casasia** под названием ***C. acunae* Fernandez et Borhidi** и морфологически отделили его от вида ***C. jacquinioides* (Griseb.) Standl.** Авторы публикуют новый ключ для определения кубинских видов **Casasia**. Внутри рода ***Antirhea*** авторы провели таксономическую обработку полиморфного вида ***A. abbreviata* Urb.** В результате этого имеется новый **status: *A. abbreviata* ssp. *obcordata* (Alain) Borhidi** и новая разновидность ***A. abbreviata* var. *moaensis* Fernandez.** Далее, авторы из рода ***Antirhea*** описывают новый вид под названием ***A. pedicellaris* Borhidi et Bisse** родственного виду ***A. multinervis* Urb.**

## ЭГРИЧЕСКАЯ МАКРОФЛОРА (ВЕРХНИЙ ОЛИГОЦЕН) ИЗ ВЕРЕЦЕМАРОШ (ВЕНГРИЯ)

Л. ХАБЛИ

Автор статьи описывает новый ископаемый вид ***Debeya hungarica* sp. n.** найденный во вновь открытом местонахождении Эгрической Флоры, Верецемарош. Другие виды вновь открытой флоры были уже известны из флоры зоценского и мелового периода. Флора Верецемарош может служить как реликт. Это доказывает тот факт, что эта флора более епло любивая и термофильная, чем другие места Эгрической флоры в Венгрии.

## АСПЕКТЫ И ТИПЫ КОМПЕТЕНЦИИ МЕЖДУ ВИДАМИ ЛИШАЙНИКОВ, ЖИВУЩИХ В ЭПИФИТНЫХ СООБЩЕСТВАХ

Т. КИШ

Автор исследовал конкуренцию между видами лишайников эпифитных сообществ. Была разработана специальная терминология для определения связей между листоватые лишайники — корковые лишайники, листоватые лишайники — листоватые лишайники, кустистые лишайники — кустистые лишайники. Результаты показали, что между отдельными колониями конкуренция очень сильная, особенно на малых поверхностях, а сукцессия оптимальна и в конечных фазах. Структура тканей и формы колонии (**thallus**) играют важную роль в определенных типах конкуренции, это очевидно в особенности между лишайниками с изрезанными листьями (**laciniatum-foliosus**) и кустистыми лишайниками. Структура ткани у лишайников ремешковой или нитчатой формы устойчива к давлению со стороны. Поэтому эти виды всегда перерастают другие виды лишайников, относящиеся к иным жизненным формам.

## КУЛЬТИВАЦИЯ IN VITRO РАСТЕНИЙ КАРТОФЕЛЯ ИЗ КУСКОВ ПРОРОСТКОВ

М. МАРОТИ, Й. РУДОЛФ, И. БОГНАР, Б. И. ПОЖАР

Авторы изучали микро-культивацию у четырех культурных разновидностей картофеля (***Solanum tuberosum* L. Bintje, Desiré, Gracia, Ostara**) Исследования производились с целью определения оптимального инокулумастебля и для сравнения влияния различных

питательных сред. По полученным результатам для изоляции самым подходяшим оказался основной верхушечный сегмент проростка, развившегося из необработанного клубня. По способности к регенерации исследованные виды можно перечислить в следующем порядке: **Ostara, Gracia, Desiré, Bintje.**

Организационное действие питательных веществ в большой степени зависит от находящихся в них качества, концентрации регулирующих веществ и их взаимодействия. Большинство растений росло на питательной среде Мурашиге – Скуг (1962), которая содержала 0,5 мг/л НУК, 0,4 мг/л кинетина и 0,7 мг/л тиамина. Примененный метод оказался приемлемым для размножения проростков картофеля **in vitro**, но нужно принять во внимание различия, которые имелись среди различных разновидностей.

## ДИНАМИКА РОСТА КАЛЛУСНЫХ ТКАНЕЙ DATURA INNOXIA MILL. ПРОИСХОДЯЩИХ ИЗ ВЕНЧИКА И ЗАВЯЗИ

А. ПОТОЦКИ, Е. СЕКЕ, Г. ВЕРЗАР-ПЕТРИ

Авторы исследовали влияние регулирующих рост веществ (кинетина и 2,4-Д) на рост трехлетних каллусных тканей *Datura innoxia* **Mill.** происходящих из венчика цветка и завязи.

Авторы определили концентрацию регулирующих рост веществ, оптимальную для образования биомассы. Авторы изучили динамику роста тканей, растущих на питательной среде Мурашиге – Скуг с добавлением 1 мг/л кинетина и 1 мг/л 2,4-Д в темноте и на свету. За 6 недель инкубационного периода был измерен свежий и сухой вес каллусных тканей, скорость роста за день и величина роста. Было определено, что оба типа каллуса за 6 недель росли нормально. Данные показали, что величина роста относящаяся к свежему и сухому весу двух типов каллуса, растущих в темноте гораздо выше, чем на свету. Скорость роста за день в любом случае имеет одну максимальную величину. Рост культуры тканей на шестой неделе замедляется, за исключением растущей на свету ткани из венчика.

## РОД *DIPLASIOLEJEUNEA* НА КУБЕ

Д. М. РЕЙЕС

После исторического вступления автор дает в статье подробное описание видов и ключа для их определения. Ранее были известны только 4 вида, произрастающие на острове, при помощи трудов автора число их повысилось на 12, среди этих видов 3 вида были описаны под названием: *D. pocsii* Reyes, *D. grolleana* Reyes и *D. borhidiana* Reyes.

По настоящим данным Куба является самым богатым местом произростания видов *Diplasiolejeunea* и в особенности восточная часть острова может быть очень важной с точки зрения специализации и филогенеза этих видов. В статье даются иллюстрации видов и карты их распространения.

## ХАРАКТЕРИСТИКА БИОЛОГИИ ОПЛОДОТВОРЕНИЯ РАЗЛИЧНЫХ ТАКСОНОВ MALUS

М. ШОЛТЕС, М. ТОТ, Ф. ДЬЮРО, А. ТЕРПО, Й. НЬЕКИ

Авторы статьи в 1977 году начали разрабатывать «Систему опыления *Malus*» в условиях Венгрии. Ньеки в 1970 году опубликовал данные о главном вопросе, об использовании видов *Malus* как пыльцевых доноров, о биологии цветения и о характере роста этих видов. Второе главное условие для благоприятного опыления, свойства биологии оплодотворения изучали в 1977 и 1978 годах Институт Садоводства в Шорокшарском Ботаническом саду и Гос. Сельскохозяйственный Сортоцепытательный Институт на опытной станции Гельвеция.

На основании двухгодичных наблюдений авторы выбрали для дальнейших исследований, в модельных насаждениях следующие виды. Для сорта яблони «Jonathan» под-

ходящими пыльцевыми донорами могут служить **SBK-3** (*M. floribunda*) и **SBK-1014**. Для сорта «**Starking**»–**SBK-1014** (*M. dasyphylla pumila*) и для «**Golden Delicious**» можно предложить **SBK-1003** (*M. domestica-pumila*).

На основании свойств биологии оплодотворения были найдены несколько подходящих видов (например **SBK-10, SBK-6, SBK-277, SBK-333**), у которых цветение, происходит одновременно вместе с сортами **Jonathan, Starking, Golden Delicious** и равно 50%. Изучая возможности исскуственного опыления в 1978 году, провели опыление сортов **Jonathan** и **Golden** смесью пыльцы и это дало некоторые, заслуживающие внимания результаты. Для **Jonathan** ♀ была использована смесь пыльцы **SBK-336** (*M. pumila*) + **Golden** (урожай показал 33% завязи) и для ♀ **Golden** – **SBK-336** + **Starking** (38,8% завязи). В «системе опыления **Malus**» можно стараться, чтобы опыление было надёжным, и поэтому для каждого сорта яблони нужно выбрать хотя бы 2 подходящих пыльцевых донора *Malus*. Авторы продолжают исследования, привлекая в опыт и другие сорта.

## ИССЛЕДОВАНИЕ ФОТОСИНТЕТИЧЕСКОЙ ФИКСАЦИИ $^{14}CO_2$ У МХОВ И ЛИШАЙНИКОВ

Я. ШУБА, К. А. ВАМОШИ, Д. ЛЕГРАДИ, Ш. ОРБАН

Авторы изучали в буковых и скалистогрунтовых сообществах фотосинтетическую продукцию мхов и лишайников. Определение усвоения $CO_2$ определяли на основе фотосинтетической фиксации $^{14}CO_2$. Усвоение $CO_2$ мхами похоже на цветковые растения, а усвоение $CO_2$ лишайниками в 5–6 раз меньше. Выделяется продуктивность вида *Rhodobryum spathulatum* которая равна 11,69 мг $g^{-1}h^{-1}$. Самую высокую фотосинтетическую интенсивность показали виды мхов **higro-** и **mesofit** по сравнению с видами **xerofit**. Мхи букового сообщества в среднем усваивают больше $CO_2$, чем мхи живушие на скалах. У лишайников большее значение показали виды *Peltigera* и *Collemma*. Обыкновенно в более рыхлой и полостной корковой части продукция фотосинтеза лишайников больше.

## МЕЙОЗ ПОЛИГАПЛОИДА МЕЖВИДОВОГО ГИБРИДА NICOTIANA, ПОЛУЧЕННОГО В КУЛЬТУРЕ ТКАНИ ПЫЛНИКА

Л. СИЛАДЬИ

В предыдущей статье автор описала аллоплоидный гибрид *N. tabacum* (**Kentucky**)× *N. glauca* хромосомным числом 2 н = 48. Было определено, что гибридные растения содержат целый геном вида *Nicotiana glauca*, а элиминация хромосом произошла из геномов. *N. sylvestris* и *N. tomentosiformis*. После сегрегации гибридных растений в последующих генерациях был получен стабильный аллоплоидный гибрид. Правильный мейоз этого растения был подтвержден полигаплоидными растениями (2 н = 2 х = 24), полученными из аллоплоида методом культуры тканей пыльников. Полигаплоидные растения показали стабильный фенотип, похожий на фенотип исходного растения с белыми цветами. *N. tabacum* (**Ky**)× *N. glauca* 2 н = 2х = 24 полигаплоид имел неправильный мейоз, который показал минимальную гомологию между тремя геномами полигаплоида (S′T′G′).

## АНАТОМИЯ ДРЕВЕСИНЫ КУБИНСКИХ ВИДОВ MYRICACEAE ЭКОЛОГИЧЕСКИЕ ЗАКЛЮЧЕНИЯ

М. А. ВАЛЕС, А. БОРХИДИ, Е. ДЕЛЬ РИСКО

Авторы опубликовывают данные по морфологии, месту обитания, экологическим связям и по анатомии вторичной ксилеммы четырех Кубинских видов **Myricaceae**: *Myrica cacuminis* **Britt. et Wild.**, *M. punctata* **Griseb.**, *M. shaferi* **Urb. et Britt.**, и *M. cerifera* **L.** На основании анатомических нумерических индексов «мезоморфии» и «ранимости» были охарактеризованы экологические свойства этих четырёх видов. Авторы на основании выше перечисленных индексов делают вывод, что из изученных видов вид *M. shaferi* и вид *M. cerifera* в большей степени приспособились к недостатку воды (**water stress**).

## ОБЗОР ГОЛОВНЁВЫХ ГРИБОВ (USTILAGINALES) ВЕНГРИИ ПРИНИМАЯ ВО ВНИМАНИЕ КОЛЛЕКЦИЮ, СОБРАННУЮ ПОСЛЕ 1950 ГОДА

К. ВАНКИ, Й. ГЕНЦЕЛЬ, Ш. ТОТ

Авторы в статье публикуют список видов венгерских головнёвых грибов, а также растений-хозяев, на которых эти грибы растут. В списке главное внимание авторы обращают на результаты коллекции собранной после 1950 года и на характеристику родов **Ustilaginales**. Среди перечисленных видов распространение 37 видов головнёвых грибов и появление на растении-хозяине 21 виданововое для Венгрии. Авторы также упоминают некоторые виды, которые еще не были собраны в Венгрии, но появление которых можно ожидать.

## ДИФФЕРЕНЦИАЦИЯ РАЗЛИЧНЫХ КУЛЬТУР ТКАНЕЙ И ОБРАЗОВАНИЕ КАННАБИНОИДА У CANNABIS SATIVA

ВЕРЗАВ-ПЕТРИ, Г., ЛАДОЧИ, Т., ОРОСЛАН, П.

Авторы получили культуры тканей каллюса венгерского сорта волокнистой конопли «Комполти». Было установлено, что культуры лучше растут на агаре Мурашиге-Скоога (Murashige—Skoog), чем на питательной почве Миллера. В равной степени были получены дифференцированные растения из семян (стерильная культура) и путём индукции листа. Дифференцированные женские и мужские экземпляры под действием гиберреллина зацвели.

Авторы описали анатомические особенности различных культур.

С помощью газовой и тонкослойной хроматографии было обнаружено, что $\Delta^9$THC (тетрагидроканнабинол) присутствовал только у дифференцированных растений. Во внешне не дифференцированном, но имеющем характерную внутреннюю дифференциацию каллюсе были выявлены всего лишь каннабиноидообразные соединения, предшественники каннабиноида.

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# PHOTOSYNTHETIC ACTIVITY IN THE STAGES OF SANDY SUCCESSION*

G. Fekete and Z. Tuba

RESEARCH INSTITUTE FOR BOTANY OF THE HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

(Received: 3 May, 1982)

Photosynthetic activity in the species of the perennial calcareous sandy grassland (*Festucetum vaginatae danubiale*) was measured in three stages of sandy succession. The dominant species, *Festuca vaginata* functioned with a high photosynthetic intensity in the pioneer stage of the vegetation development; with the advance of the succession (closure of sward) this intensity decreased. It is feasible that this is due to the different ages of the individuals, in senescence. With succession advancing, also the photosynthetic activity of the stand falling on unit area decreases. Photosynthetic production falling on unit green biomass gradually declines also, in this respect the differences among the three stands are significant.

Recently, the stress generated by the different habitats in establishing the physiological tolerance of the species has become accentuated. Some (e.g. Drury and Nisbet 1973) consider the driving force promoting the ecological succession directly in such adaptations.

We already have data, which are delineating our ideas on the main ecophysiological properties which are characteristic for the early or just for the late successional species (Bazzaz 1979). Little is known, however, about how the ecophysiological parameters are formed with one and the same species during the succession. From the point of view of survival and competition, photosynthesis is perhaps the most fundamental physiological process. Here the photosynthetic activity is described which changes in some stages of sandy succession, according to our investigations. Although the measurements were carried out on individuals of certain species, the photosynthetic activity of the vegetation stands has also been estimated.

## Material and methods

The investigation was carried out on the sandy region near Fülöpháza lying 25 kms west to the town of Kecskemét, on the Great Hungarian Plain, in the Danube–Tisza Interfluve, constituting a separate and uniform part of the Kiskunság National Park. It is a sand-hill country of uneven terrain, the greater part of the dunes has been already stabilized, with the exception of some active sand dunes still moving at the present time. The vegetation is perennial calcareous sandy grassland (*Festucetum vaginatae danubiale*). The sample plot was marked out on the largest shifting sand dune.

The *Festuca vaginata* appeared already in the pioneer stage (I), forming strikingly large, virulent tufts. On the investigation site *Centaurea arenaria*, *Salsola kali*, *Cenchrus tribuloides*, *Bromus tectorum* are also typical in the open sward.

* Tece studies No. 25

On the almost bound sloping foot of the hill (stage II) the *Scabiosa ochroleuca*, *Alyssum montanum* ssp. *gmelinii*, *Euphorbia seguieriana*, *Stipa capillata*, *Koeleria glauca* can be found more frequently.

Stage III is closed by more than 60%, and such swards, advanced in succession, are monotonous, besides the predominance of *Festuca vaginata* only the *Stipa* species (*S. capillata*, *S. sabulosa*), some individuals of *Euphorbia seguieriana* and some other species can be found only sparsely.

It is to be noted that the successional stages were not established with respect to time. The criterion was the increasing closure of the stands taking up different positions in space, but the geomorphology of the moving sand dune as well as the composition of vegetation afforded evidence for the relative age and successional development of stands. For the description of the sample plot and successional stages refer to FEKETE and MELKÓ (1981).

The photosynthetic activity was measured by a portable apparatus on the site, which is a bent glass pipe with mercury seal from which the carbon dioxide was released from $BaCO_3$ containing 14-C. Its activity is 0.5 millicurie/minute, concentration of $CO_2$ is 0.5%. After detaching the leaves they were immediately placed into the equipment and exposed for 1 minute. Then the exposed material, which had been placed between blotting papers, was killed by a hot iron. The 14-C incorporation was measured at the Eötvös Loránd University of Science by Beckman — LS 100 liquid-scintillating equipment, in cpm.

## Results

### Individual level

#### *Festuca vaginata*

It is the most important, eponymous species of the community, it is, so to say, the only one which can be dominant in all stages of sandy succession, as far as the semi-closed forests, which, however, were missing from the sample plot. (Vegetation development here reached only the loose white poplar-juniper groups of trees, bushes; the *Junipereto-Populetum* of the neighbouring sandy regions of the Danube–Tisza Interfluve, however, does not grow here and forests, closer, more continuous stands cannot be found at all.) *Festuca vaginata* plays a prominent part also in stabilizing the shifting sand though it is not propagated by below ground vegetative organs and has not tillers, rhizomes but its tufts tolerate well the sand coverage renewed from time to time. I can also tolerate the loose shading and can be found also in the *Salix rosmarinifolia* shrub of the depressions between the dunes.

Measurements were made 3 times, at the time of flowering (1980) and thereafter (1980, 1981).

It can be seen that with the advance of the succession the photosynthetic intensity decreases. The rate of decrease is roughly so that — leaving stage II, 1981/7 out of consideration — the amount of the incorporated carbon dioxide drops to one half its previous level from stage to stage. It is also to be noted that while there is good agreement in the proportions and tendencies, conspicuous differences may be found in the absolute values, according to the times of measurements.

The photosynthetic values of other species occurring in the stands of 1 m$^2$ of the 3 stages, marked out for measuring are included in Table 2. It can be seen that only *Festuca vaginata* is common in the 3 stages, furthermore annuals missing from the other stages can also be found in the pioneer stage I. Stage III, here too, is characterized by the predominance of a few species.

**Table 1**

*Gross photosynthesis values in Festuca vaginata, mg $CO_2$ $g^{-1}h^{-1}$, in the three stages of sandy succession. Averages of 10 each (in 1981: 5 repetitions each)*

| Stages | 30. 6. 1980 | 16. 7. 1980 | 16. 7. 1981 |
|---|---|---|---|
| I | 1.212 | 0.328 | 0.042 |
| II | 0.641 | 0.127 | 0.027 |
| III | 0.347 | 0.089 | 0.027 |

**Table 2**

*Gross photosynthesis values in dominant species in the stages studied of sandy succession, mg $CO_2$ $g^{-1}h^{-1}$. Averages of 5 repetitions each. 16. 7. 1981*

| Stages | | |
|---|---|---|
| I | *Salsola kali* | 0.111 |
| I | *Festuca vaginata* | 0.042 |
| I | *Cenchrus tribuloides* | 0.052 |
| I | *Centaurea arenaria* | 0.070 |
| II | *Scabiosa ochroleuca* | 0.045 |
| II | *Festuca vaginata* | 0.027 |
| II | *Euphorbia seguieriana* | 0.080 |
| III | *Stipa capillata* | 0.023 |
| III | *Festuca vaginata* | 0.027 |

## Supraindividual level

Values in Table 2 enable an estimate to be made of the photosynthetic productivity of all the stands representing the stages. 5 stands for each stage were selected and such whose composition covers the species listed in Table 2. In every square metre of area the biomass of the above ground green parts was measured species by species (in dry weight). With this, the values of photosynthetic intensity in each species were weighted, thus obtaining the photosynthetic values of the stand (Table 3, 4).

**Table 3**

*Photosynthesis of stands*
A: biomass, g $m^{-2}$; B: stand photosynthesis intensity, mg $CO_2$ $m^{-2}h^{-1}$;
C: stand photosynthesis per unit biomass, mg $CO_2$ $g^{-1}h^{-1}$. 16. 7. 1981

| Stages | Repetitions | A | B | C |
|---|---|---|---|---|
| I | 1 | 27.06 | 1.905 | 0.070 |
| I | 2 | 26.57 | 1.462 | 0.055 |
| I | 3 | 45.24 | 2.551 | 0.056 |
| I | 4 | 29.60 | 1.765 | 0.060 |
| I | 5 | 37.54 | 2.257 | 0.060 |
| II | 1 | 12.76 | 0.470 | 0.037 |
| II | 2 | 26.48 | 0.984 | 0.037 |
| II | 3 | 11.14 | 0.442 | 0.040 |
| II | 4 | 8.70 | 0.414 | 0.048 |
| II | 5 | 14.33 | 0.885 | 0.062 |
| III | 1 | 21.26 | 0.530 | 0.025 |
| III | 2 | 15.80 | 0.392 | 0.025 |
| III | 3 | 31.55 | 0.815 | 0.026 |
| III | 4 | 23.61 | 0.609 | 0.026 |
| III | 5 | 35.06 | 0.868 | 0.025 |

**Table 4**

*Stand photosynthesis, mg $CO_2$ $m^{-2}h^{-1}$. 16. 7. 1981.*
Averages and significance levels of their differences

| Stages | I | II | III |
|---|---|---|---|
| I | 1.988 | *** | *** |
| II | | 0.639 | NS |
| III | | | 0.643 |

*** $P < 0.1\%$

*Stand photosynthesis per unit biomass, mg $CO_2$ $g^{-1}h^{-1}$.*
Averages and significance levels

| Stages | I | II | III |
|---|---|---|---|
| I | 0.060 | ** | *** |
| II | | 0.045 | *** |
| III | | | 0.025 |

** $P < 1\%$, *** $P < 0.1\%$

## Discussion

The photosynthetic productivity of the *Festuca vaginata* separating from stage to stage can be considered a surprising result which is difficult to explain at present. As we have described in a previous study (FEKETE and MELKÓ l.c.), the weight of an average individual of the species (green biomass) as well as the proportions of the plant parts (fertile part: spica + inflorescence axis; assimilation organs; root) differ widely in the three stages. (For example it is enough to quote that in the pioneer stage the average dry weight of an individual is 111.6 g while in the closed stage III it is only 6.59 g.) A considerable amount of leaves just withering and hardly or only partly functioning, can be seen on each individual in the closed stand, the closure of the sward is greatly determined just by this heap of leaves being on the brink of ruin. Perhaps, in the pioneer stage nothing but young individuals can be found while in the other two stages, older individuals; unfortunately, no method is at our disposal for an objective establishment of the ages of the *Festuca* tufts. The results mentioned above indicate that with respect to allocation, i.e. at the physiological level, differences, displacements according to the successional stages can be observed. (Such a difference is for example, that the reproductive allocation is determined in stage I mainly by the green assimilation parts, in stage II by the mass of root, while in stage III the effect of both is negligible.) The present series of investigations — even if due to the difference in methods cannot be directly compared with the previously mentioned ones — indicate the influence of the community on the physiological functions. The importance of the photosynthetic activity at the beginning of colonization is emphasized by both approaches.

The photosynthetic production falling to 1 m$^2$ of the stands declines from stage I to stage III. Consequently, in the multispecies community the same tendency can be observed as in the population of the dominant species. The productivity of the first pioneer stage is prominent, it can be verified statistically too (Tables 3, 4). Moreover this is confirmed if the photosynthetic production is calculated for 1 g biomass of the stands. Especially the repetitions of stage III produce a uniform result; at this time stages II and III, too, separate from each other.

ODUM's bioenergetic explanation (1969) on the development of the ecosystem is reinforced by the results. The P/B ratio may in all likelihood be a concomitant of the development of the perennial sandy grassland, too.

Furthermore the data in Table 3 and the statistical investigations confirm the authors' conviction that such a physiological activity as photosynthesis, as regards its intensity, is supraindividually regulated in natural communities. The authors have proved this fact earlier (FEKETE and TUBA 1977) in a community of an other kind (in the light limited layers of an oak

forest) by demonstrating an intense supraindividual homogeneity of photosynthetic pigments. These present results suggest that this phenomenon may occur in open communities less organized and saturated than a forest and with fewer species number.

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# CHEMICAL COMPOSITION OF THE LESSER REEDMACE (TYPHA ANGUSTIFOLIA L.) IN LAKE BALATON

Margit Kovács

RESEARCH INSTITUTE FOR BOTANY OF THE HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT

(Received: 3 May, 1982)

In the littoral zone of Lake Balaton, under the influence of eutrophisation the *Typha angustifolia* keeps spreading to the detriment of reeds. Quantities of N, P, Ca, Mg, K, Na, Sr, Fe, Mn, Zn, Pb, Cu as well as that of the micro- and ultramicro elements have been determined in the different organs of the reedmace (leaf, stem, rhizome, root, rootlet). The difference of the elements is of lesser extent in the different organs than in those of the reed.

Na and Cl accumulation is a specific feature of *Typha angustifolia*. It can take larger quantity of both elements than *Phragmites communis. Typha angustifolia* can mainly take alkali metals (K, Na), alkali earth metals (Ca, Mg, Sr) as well as Cl and Zn in larger quantities.

By applying spark-source mass spectrographic investigations, 34 micro-, ultramicro and rare elements, respectively, can be detected in the different organs of the reedmace.

In the last ten years two species (*Stratiotes aloides, Typha angustifolia*) which accumulate alkali metals and alkali earth metals can be observed along the whole length of the northern shore of Lake Balaton. Spreading in large numbers of both species indicates the changes taking place in the environment (water and sediment) of Lake Balaton.

## Introduction

In the littoral zone of Lake Balaton *Typha angustifolia* is a frequent stand-constituting species the spreading of which to the detriment of reeds can be observed not only here but in several eutrophic lakes of Europe. Its homogeneous stands can often be found mainly on the shore sections loaded with sewage, where the original sandy sediment is covered by mud in a thickness of several decimeters.

To determine the part of the water macrophytons played in the nutrient circulation of the lake-ecosystem it is essential to know what quantity of elements these plants are able to take from the sediment (and from the water) depending on the geochemical environment and on the extent of load.

At present, at each sewage purificator a large quantity of the different elements (mainly N, P, Na, Cl) gets into Lake Balaton and thus the biological sewage purification takes place in the littoral zone, by the aid of the flora and fauna living there. On the basis of the chemical composition of the plants, e.g. of the lesser reedmace, it can be determined with what efficiency the plants are able to eliminate the individual "loading"-elements.

## Material and method

The material was collected from several spots of the Keszthely-bay and the northern shore in the July of 1977, 1979 and 1981. The littoral zone near the sewage inlet of Balaton-

füred also was a sample plot. From each plot 10 plants have been collected, which were carefully cleaned with water and distilled water and were taken to the following organs: leaf, shoot, rhizome, root and rootlet.

KJELDAHL-nitrogen, phosphorus (Contiflo-series analyser), the contents of Ca, K and Na (flame-photometer) as well as the quantity of Mg, Sr, Fe, Mn, Zn, Cu and Pb (Unicam Atomic-absorption spectrophotometer) were determined.

The contents of micro- and ultramicro elements were determined in the Central Research Institute for Physics of the Hungarian Academy of Sciences (OPAUSZKY, I. and NYÁRI, I.), by means of the spark-source mass spectrometer.

## Results of investigation

### *Contents of elements and accumulation capacity of Typha angustifolia*

*Typha angustifolia*, like the other water macrophytons, is characterized by a defined chemical composition mainly in the macro-nutrients, with a defined intraspecific variation, which depends on the age, state of development of the plants (phenological difference — to eliminate this, sampling was performed at the same time), on the plant organs (morphological difference), furthermore on the habitat (geochemical difference).

## Morphological and geochemical difference

The different organs of the bulrush comprise the investigated macro- and micro-elements in different quantity (Table 1) but this difference in quantity is of smaller extent than with the reed (KOVÁCS, PRÉCSÉNYI and PODANI 1978).

The macro-elements (N, P, Ca, Mg, K, Na) can be detected in the largest quantity in the under-ground organs and in the leaves while the micro-elements (Sr, Fe, Mn, Zn, Pb, Cu) in the rootlet and root (Table 1).

Nitrogen can be found in the largest quantity in the leaves (1.07–2.26% and rootlets (0.87–1.19%). On the shore sections loaded with sewage (e.g. Balatonfüred) the nitrogen contents of the leaf is 1.96–2.57% (Table 2).

Comparing the leaves of the reed with those of the lesser reedmace, the accumulation capacity related to the nitrogen is lesser by some 40–50% in the latter. The factor of nitrogen concentration* is smaller in the reedmace than in the reed (Table 3).

Higher contents of phosphorus is also characteristic of the leaves and under-ground organs (Table 1). This quantity is 0.27–0.45% at the sewage inlets (Table 2).

* Calculations for concentration-factor have been accomplished with the reed and reedmace at the sewage purificator of Balatonfüred, related to the element contents of the sediment.

$$\text{Concentration-factors} = \frac{\text{element-contents of the plant/organ/mg/100 g}}{\text{element-contents of the sediment mg/100 g}}$$

**Table 1**

*Chemical composition of Typha angustifolia (in %) related to dry weight*

| | | | 1976<br>n: 7<br>$\bar{x}$ | 1977<br>n: 9<br>$\bar{x}$ |
|---|---|---|---|---|
| Leaf | ash | % | 6.96 | 6.84 |
| | N | % | 1.58 | 1.88 |
| | P | % | 0.18 | 0.14 |
| | Ca | % | 0.30 | 0.39 |
| | Mg | % | 0.30 | 0.43 |
| | K | % | 1.07 | 1.27 |
| | Na | % | 0.68 | 0.97 |
| | Sr | ppm | 15 | 23 |
| | Fe | ppm | 90 | 268 |
| | Mn | ppm | 102 | 172 |
| | Zn | ppm | 20 | 25 |
| | Pb | ppm | 16 | 12 |
| | Cu | ppm | 3 | 6 |
| Shoot | ash | % | 7.90 | 7.79 |
| | N | % | 0.53 | 0.87 |
| | P | % | 0.12 | 0.11 |
| | Ca | % | 0.47 | 0.70 |
| | Mg | % | 0.35 | 0.32 |
| | K | % | 1.26 | 1.31 |
| | Na | % | 1.04 | 1.50 |
| | Sr | ppm | 28 | 33 |
| | Fe | ppm | 221 | 152 |
| | Mn | ppm | 105 | 71 |
| | Zn | ppm | 28 | 16 |
| | Pb | ppm | 12 | 11 |
| | Cu | ppm | 3 | 4 |
| Rhizome | ash | % | 12.68 | 10.76 |
| | N | % | 0.88 | 1.09 |
| | P | % | 0.21 | 0.14 |
| | Ca | % | 0.49 | 0.70 |
| | Mg | % | 0.41 | 0.40 |
| | K | % | 1.96 | 1.67 |
| | Na | % | 0.96 | 1.53 |
| | Sr | ppm | 19 | 29 |
| | Fe | ppm | 1396 | 1367 |

| | | | 1976 n: 7 $\bar{x}$ | 1977 n: 9 $\bar{x}$ |
|---|---|---|---|---|
| | Mn | ppm | 42 | 70 |
| | Zn | ppm | 26 | 24 |
| | Pb | ppm | 17 | 13 |
| | Cu | ppm | 6 | 5 |
| Root | ash | % | 11.52 | 18.95 |
| | N | % | 0.85 | 0.93 |
| | P | % | 0.12 | 0.13 |
| | Ca | % | 0.58 | 1.78 |
| | Mg | % | 0.48 | 0.66 |
| | K | % | 0.55 | 0.60 |
| | Na | % | 0.85 | 1.22 |
| | Sr | ppm | 41 | 77 |
| | Fe | ppm | 2240 | 6064 |
| | Mn | ppm | 86 | 233 |
| | Zn | ppm | 67 | 79 |
| | Pb | ppm | 20 | 23 |
| | Cu | ppm | 3 | 4 |
| Root hair | ash | % | — | 16.48 |
| | N | % | — | 1.02 |
| | P | % | — | 0.24 |
| | Ca | % | — | 2.74 |
| | Mg | % | — | 0.51 |
| | K | % | — | 0.63 |
| | Na | % | — | 0.35 |
| | Sr | ppm | — | 113 |
| | Fe | ppm | — | 10406 |
| | Mn | ppm | — | 389 |
| | Zn | ppm | — | 74 |
| | Pb | ppm | — | 47 |
| | Cu | ppm | — | 13 |

It is a characteristic feature of species that each organ of the plant contains the nitrogen in relatively large quantity (cp. with the data also published by DYKYJOVA 1979). The Na content of the leaves is higher by 7–23 times than that of the reed. This ratio may be even by 19–63 times higher near the sewage inlets (Balatonfüred). Its Na concentration-factor is high in the different organs, it is 353 in the stem on sandy-sediment and 142 in muddy sediment (Table 3).
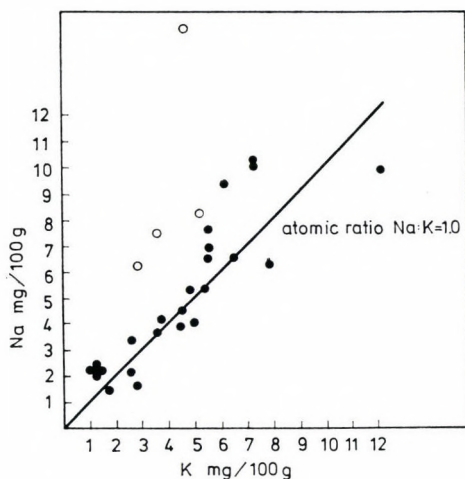
*Fig. 1.* Ratio of Na and K concentration in the leaves of the reed and lesser reedmace; — white circles: reedmace, black circles: reed

*Typha angustifolia* has higher Na-uptake plasticity than the reed.

As to the K–Na absorption the bulrush differs considerably from the reed (Fig. 1). The accumulation capacity of the reedmace corresponds to the K/Na ratio and to the quantity in the sediment, respectively (Fig. 2).

Ca and Mg can be detected in larger quantities in the under-ground organs, rootlet (mainly Ca) as well as in the shoot.

Of the heavy metals iron and manganese can be measured in larger quantity. Iron is accumulated mainly in the rhizome, root and rootlet, in the
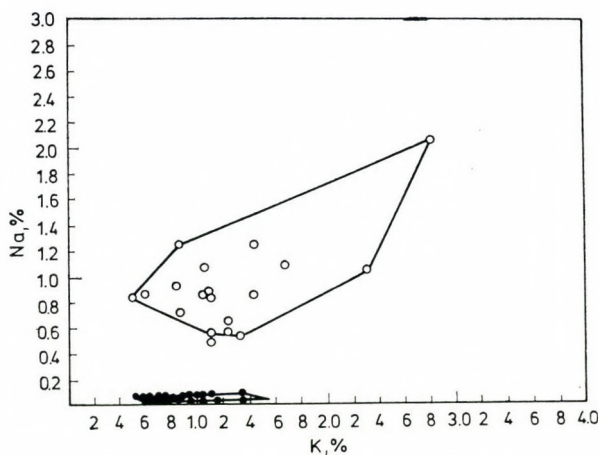
*Fig. 2.* Ratio of Na and K concentration in the shoot of the reed and lesser reedmace (calculated for dry material); — white circles: reedmace, black circles: reed

**Table 2**

*Chemical composition of Typha angustifolia to dry*

| Organs of the plant | Sample number | Ash, % | Ca | K | Na | Mg |
|---|---|---|---|---|---|---|
| | | | | | | ppm |
| Leaf-blade | 4/26 | 9.3 | 0.59 | 1.64 | 1.19 | 0.40 |
| Leaf sheath | 28 | 18.1 | 0.07 | 1.67 | 1.66 | 0.32 |
| Shoot | 29 | 7.7 | 0.38 | 0.90 | 1.54 | 0.35 |
| Rhizome | 30 | 13.5 | 0.56 | 1.23 | 1.79 | 0.35 |
| Root | 31 | 10.7 | 0.94 | 0.38 | 1.06 | 0.52 |
| Buds | 33 | 16.7 | 0.44 | 4.26 | 1.08 | 0.21 |
| Fruiting inflorescence | 32 | 6.8 | 0.34 | 1.90 | 0.15 | 0.37 |
| Leaf-blade | 7/50 | 7.9 | 0.56 | 0.90 | 1.26 | 0.51 |
| Leaf sheath | 51 | 11.1 | 0.88 | 0.83 | 2.20 | 0.49 |
| Shoot | 52 | 16.8 | 0.66 | 2.36 | 2.84 | 0.48 |
| Rhizome | 54 | 10.9 | 0.63 | 0.98 | 1.78 | 0.65 |
| Root | 52 | 19.7 | 1.54 | 0.98 | 2.12 | 0.86 |

latter organ even a quantity of 14,000 ppm could be measured. Zinc and lead can be found in larger quantity also in the root and rootlet.

At the sewage purificator of Balatonfüred, where Zn-load cannot be left out of account, the Zn content of the rootlets reaches the quantity of 199–269 ppm (Table 2).

With the communal sewages as well as with the Sodium-hypochlorite ("Hypo") used in the purifying works, besides the free chlorine also a larger quantity of chloride gets into the water of Lake Balaton.
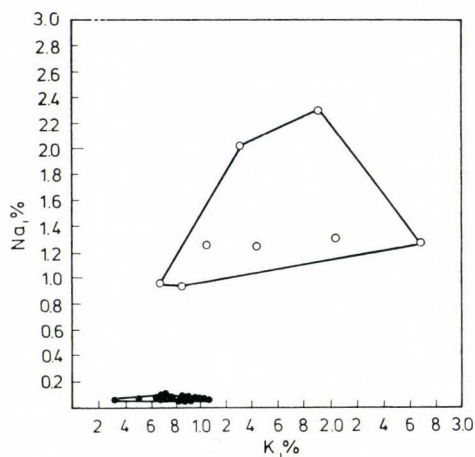
*Fig. 3.* Ratio of Na and K concentration in the sediment; — white circles: at Balatonfüred in front of the sewage purificator, black circles: in the Bay of Keszthely

*weight (in % and ppm) Sewage inlet near Balatonfüred*

| N | P | Cl | Sr | Fe | Mn | Zn | Cu | Cd |
|---|---|---|---|---|---|---|---|---|
| 2.57 | 0.45 | 3.00 | 24 | 141 | 68 | 32 | 6 | 1.2 |
| 1.05 | 0.44 | 5.60 | 18 | 209 | 20 | 23 | 3 | 0.7 |
| 0.98 | 0.28 | 2.30 | 15 | 27 | 18 | 45 | 2 | 0.4 |
| 1.13 | 0.38 | 1.70 | 22 | 1542 | 28 | 44 | 7 | 0.8 |
| 1.00 | 0.34 | 0.53 | 59 | 3588 | 61 | 209 | 13 | 1.9 |
| 1.64 | 0.33 | 1.60 | 98 | 470 | 39 | 53 | 6 | 3.9 |
| 2.17 | 0.49 | 0.98 | 12 | 110 | 65 | 46 | 7 | 0.7 |
| 1.96 | 0.27 | 2.73 | 21 | 92 | 13 | 23 | 2 | 0.4 |
| 0.90 | 0.19 | 3.10 | 45 | 68 | 11 | 22 | 3 | 0.9 |
| 1.30 | 0.43 | 4.67 | 17 | 81 | 7 | 67 | 3 | 1.0 |
| 1.11 | 0.30 | 2.13 | 21 | 272 | 11 | 42 | 4 | 0.9 |
| 1.34 | 0.28 | 0.82 | 77 | 2198 | 28 | 288 | 12 | 1.7 |

**Table 3**

*Concentration-factor of the elements in Phragmites communis and Typha angustifolia, on sandy and muddy sediments*

| Phragmites communis | Na | | Cl | |
|---|---|---|---|---|
| | sandy | muddy | sandy | muddy |
| | sediments | | | |
| *Phragmites communis* | | | | |
| Leaf-blade | 5 | 2 | 57 | 32 |
| Leaf sheath | 20 | 8 | 65 | 37 |
| Shoot | 18 | 7 | 42 | 24 |
| Rhizome | 46 | 18 | 50 | 29 |
| Root | 160 | 64 | 39 | 22 |
| Rootlets | 117 | 47 | 39 | 22 |
| *Typha angustifolia* | | | | |
| Leaf-blade | 197 | 79 | 191 | 110 |
| Leaf sheath | 312 | 125 | 290 | 167 |
| Shoot | 353 | 142 | 232 | 134 |
| Root | 174 | 70 | 106 | 61 |

**Table 4**

*Contents of micro- and ultramicro-elements in the organs of Typha angustifolia (Alsógyenesdiás), in ppm*
(measured by I. OPAUSZKY and I. NYÁRI)

| Elements | Leaf | Shoot | Rhizome | Root |
|---|---|---|---|---|
| Bi | — | — | — | 0.16 |
| Pb | 2.91 | 2.12 | — | 8.05 |
| Gd | — | — | — | 1.29 |
| Sm | — | — | — | 3.22 |
| Nd | — | — | — | 5.63 |
| Pr | 0.06 | 0.28 | 0.22 | 1.61 |
| Ce | 0.23 | 0.28 | 0.44 | 6.44 |
| La | 0.06 | 0.14 | 0.22 | 2.75 |
| Ba | * | 35.38 | 54.94 | ** |
| Cs | 0.11 | 0.14 | 0.33 | 1.29 |
| I | 0.23 | — | 0.88 | 0.48 |
| Sb | 0.35 | 1.96 | 0.22 | 1.61 |
| Sn | 0.29 | 0.71 | 49.45 | 7.24 |
| Ag | — | 0.42 | 1.43 | — |
| Mo | 0.58 | 1.77 | 1.10 | 4.02 |
| Nb | 0.06 | 0.14 | 1.10 | 1.61 |
| Zr | 0.29 | 0.14 | 1.10 | 6.44 |
| Y | 0.06 | 0.07 | 0.22 | 3.22 |
| Sr | ** | * | ** | ** |
| Br | + | + | + | — |
| As | + | + | + | — |
| Ga | 0.29 | 0.71 | 1.10 | 7.24 |
| Zn | 20.39 | 12.03 | 36.26 | 128.82 |
| Cu | 14.57 | 8.49 | 24.17 | 96.62 |
| Ni | 8.74 | 4.24 | 1.65 | 43.48 |
| Co | 0.23 | 0.28 | 0.44 | 6.44 |
| Fe | ** | ** | *** | *** |
| Mn | ** | * | ** | ** |
| Cr | 9.90 | 1.41 | 7.69 | 64.41 |
| V | 0.87 | 0.28 | 1.65 | 51.53 |
| Ti | 34.96 | 16.28 | ** | *** |
| F | 0.58 | 0.71 | 0.55 | 4.02 |
| B | 5.24 | 12.03 | 3.84 | 27.37 |
| Al | ** | 24.77 | *** | *** |

\+ = data for information
* = 0.1–0.2 mg%
** = 0.2–1.0 mg%
*** = above 1 mg%

**Table 5**

*Contents of micro- and ultramicro-elements in the organs of Typha angustifolia (Keszthely), in ppm*
(measured by I. Opauszky and I. Nyári)

| Elements | Leaf/shoot | Rhizome | Root |
|---|---|---|---|
| Pb | 2.70 | 1.21 | 52.74 |
| Nd | 0.43 | 1.69 | 14.77 |
| Pr | 0.11 | 0.24 | 2.11 |
| Ce | 0.43 | 2.42 | 21.10 |
| La | 0.22 | 1.21 | 6.33 |
| Ba | * | * | ** |
| Cs | 0.02 | 0.60 | 6.33 |
| I | 1.08 | 0.12 | 0.21 |
| Sb | 0.22 | 0.18 | 3.16 |
| Sn | 0.54 | 0.36 | 5.27 |
| Mo | 1.08 | 1.21 | 2.11 |
| Nb | 0.06 | 0.14 | 5.27 |
| Zr | 1.39 | 1.45 | 25.32 |
| Y | 0.27 | 0.30 | 12.66 |
| Sr | ** | ** | ** |
| Rb | * | * | * |
| Br | 21.64 | 12.09 | 2.11 |
| As | 0.11 | 0.60 | 4.22 |
| Ga | 0.54 | 0.30 | 10.55 |
| Zn | 32.47 | 36.28 | 316.46 |
| Cu | 14.07 | 72.55 | 52.74 |
| Ni | 1.62 | 3.63 | 31.64 |
| Co | 0.43 | 1.81 | 30.60 |
| Cr | 1.62 | 4.84 | 84.39 |
| V | 1.62 | 3.63 | 63.29 |
| Ti | 27.06 | 72.55 | 1265.82 |
| Sc | 0.13 | 0.07 | 2.53 |
| F | 1.30 | 0.06 | 0.10 |
| B | 12.99 | 0.36 | 1.27 |

* = 0.1 mg%
** = 0.1–1.0 mg%

While the chloride-uptake of the reed is independent of the load, the lesser reedmace is able to take up a larger quantity of Cl, similarly to Na. At the sewage inlet of Balatonfüred the chloride content of the individual

organs was as follows, the data for the reedmace deriving from the shore section not loaded with Cl (Keszthely) are given between brackets.

| | | |
|---|---|---|
| leaf | 2.73–3.00% | (0.67–1.40%) |
| shoot | 2.30–4.60% | (0.95–2.90%) |
| rhizome | 1.70–2.13% | (1.63%) |
| root | 0.82–1.60% | (0.80%) |

Some 60–70% of the chloride quantity in the reedmace can be found in the above-ground organs. The factor of the chloride concentration, similarly to that of Na, is also high, it is 191 in the leaf in sandy sediment and 110 in mud sediment (Table 4).

Following from its species specific feature *Typha angustifolia* plays an important part mainly in the Na and Cl elimination and, by accumulating these two elements, it is able to decrease to a certain extent the salinity of the water. It is able to take in larger quantity mainly alkali metals (K, Na), alkali earth metals (Ca, Mg, Sr) as well as Cl and Zn.

The phenomenon must be taken notice that in the last one or two decades the spread of such two plant species can be observed along the whole length of the northern shore in which alkali metals and alkali earth metals can be detected in larger quantities. One is *Typha angustifolia* and the other is *Stratiotes aloides*, which differs in its chemical composition from the other reed-grass species of Lake Balaton (Kovács and Tóth 1979). From the spreading in great numbers of both species the conclusion can be drawn that changes have taken place in the environmental (water and sediment) circumstances of Lake Balaton.

## Contents of micro- and ultramicro elements

From the contents of micro- and ultramicro-elements of the reedmace the geochemical conditions of Lake Balaton and the load deriving from the industrial-agricultural activity can be inferred.

According to the investigations carried out up to now, 37 elements could be detected in the different organs of *Typha angustifolia* (Tables 4 and 5). The elements taken from the sediment are translocated in the individual organs in different quantities. The investigated elements can be detected in larger quantities mainly in the root and rhizome. According to the investigations carried out up to now, Bi, Gd and Sm could be found only in the root. Of the elements the following 16 elements can be qualified, according to Wood (1974), as toxins: Bi, Pb, La, Ba, Sb, Sn, Ag, Nb, Zr, As, Ga, Zn, Cu, Ni, Co, Ti. With the accumulation of the listed elements *Typha angustifolia* is able to reduce the toxic effect hereof.

## Summary

*Typha angustifolia*, which keeps gradually spreading under the influence of eutrophication plays an important role near the sewage inlets in the biological water purification.

Due to its specific feature of species it is able to accumulate Na and Cl in larger quantity depending on the load while the accumulation capacity of the reed makes the uptake mainly of nitrogen and phosphorus of higher quantity possible. As Na and Cl accumulated mainly in the above-ground organs of the reedmace the accumulated quantity of elements can be removed from the lake by a winter cutting.

According to our investigations performed up till now *Typha angustifolia* reduces the toxic effect of 16 elements by accumulating them. The micro- and ultramicro-elements are accumulated in relatively larger quantities mainly in the rhizome and root.

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# CATÁLOGO DE LAS PALMAS DE CUBA

O. Muñiz[1] y A. Borhidi[2]

[1] INSTITUTO DE GEOGRAFÍA DE LA ACADEMIA DE CIENCIAS DE CUBA, LA HABANA
[2] INSTITUTO DE BOTÁNICA DE LA ACADEMIA DE CIENCIAS DE HUNGRÍA, VÁCRÁTÓT

The new checklist of the Cuban palms contains 18 genera, 85 species and 12 infraspecific taxa, based on the recent discoveries and up to date results. The taxa are listed in a new phylogenetic order according to H. E. Moore jr. provided with new analytic keys for identification and synonyma. A number of new taxa, combinations and status is also contributed. These are: *Hemithrinax* sect. *Macrocarpae* (León) Muñiz stat. n., *Hemithrinax rivularis* var. *savannarum* (León) Muñiz comb. et stat. n., *Coccothrinax* sect. *Longispadiceae* (León) Muñiz stat. n., *Coccothrinax* subsect. *Multiramosae* (León) Muñiz stat. n. *Pauciramosae* (León) Muñiz stat. n., *Coccothrinax clarensis* ssp. *brevifolia* (León) Borhidi et Muñiz stat. n., *Coccothrinax* subsect. *Haitiella* (Bailey) Muñiz comb. et stat. n., *Copernicia* sect. *Ekmanianae* Muñiz sect. n., sect. *Albae* Borhidi et Muñiz sect. n., *Copernicia* subsect. *Fallaenses* Muñiz et Borhidi subsect. n., subsect. *Roigianae* Muñiz et Borhidi subsect. n., *Copernicia × Burretiana* (León) Muñiz et Borhidi stat. n., *Copernicia × occidentalis* (León) Muñiz et Borhidi stat. n., *Copernicia glabrescens* var. *ramosissima* (Burret) Muñiz et Borhidi comb. et stat. n., *Calyptronoma Clementis* ssp. *orientensis* Muñiz et Borhidi ssp. n.

## Introducción

Cuba, con respecto a su territorio relativamente pequeño, tiene una flora muy rica en palmas, las que juegan un papel importante en el aspecto de sus paisajes, en la fisionomía de su vegetación y en la vida de su pueblo, que las aplica para varios usos.

Las primeras espécies de las palmas cubanas fueron colectadas y descritas por Humboldt, Bonpland y Kunth (1815), por Martius (1838) y por A. Richard (1850). La primera colección de mayor importancia fue realizada por Ch. Wright entre 1855 y 1865. Este material valioso se elaboró H. Wendland y A. Grisebach en varios articulos y obras (1865, 1866, 1871, 1873, 1879). Sus trabajos y las colecciones de Curtiss quedaron revisados y elaborados críticamente en las obras fundamentales de Beccari (1907, 1912). Las colectas de Shafer, Britton y Wilson (1914) resultaron el descubrimiento de otras dos espécies más, mientras Ekman descubrió 8 espécies nuevas de las palmas cubanas, descritas por Burret en 1929.

El trabajo decisivo lo asumó H. León, quien durante 3 decenas de años exploraba sistematicamente todo el territorio del pais, colectando y estudiando todos los géneros de palmas existentes en Cuba. En una serie de estudios notables (*Copernicia* 1931, 1936, *Coccothrinax* 1939, *Acrocomia* 1940, *Hemithrinax* 1941, *Roystonea* 1943, *Calyptrogyne* 1944) publicaba 44 taxones nuevos con las cuales el sólo logró a descubrir más espécies de palmas en Cuba, que todos los demás botánicos. El primer, y hasta ahora el ultimo resumen completo de las palmas cubanas ha sido publicado por el mismo H. León en el primér tomo de la Flora de Cuba (1946), lamentablemente sin claves analíticas y con descripciones muy cortas.

En los ultimos 20 años se publicaron una serie de resultados nuevos e importantes al respecto de la filogenética y taxonomía (Satake 1962, Potztal 1964, Moore 1969, 1972, 1973, Moore y Uhl 1973), de la citotaxonomía (Read 1963–1968, Read y Moore 1971) de la anatomía y morfología (Tomlinson 1960, 1961, 1967, 1969, 1971, Uhl 1966, 1969, 1972,

UHL y MOORE 1971) de las palmas. Además de estos se publicaron algunos estudios críticos importantes para la flora de Cuba (DAHLGREN y GLASSMAN 1963, MOORE 1967, 1971, READ 1975) y descubrieron otras nuevas espécies mas BORHIDI y MUÑIZ 1971, MUÑIZ in BORHIDI, IMCHANITZKAJA y MUÑIZ 1978, MUÑIZ y BORHIDI 1982).

Ha sido preciso, que a base de estos resultados realizáramos un catálogo completo y moderno de las palmas de Cuba, que presenta una enumeración de todos los taxones en un orden filogenético moderno, con los sinónimos, claves analíticas nuevas y resultados taxonomicos nuevos.

## Fam.: ARECACEAE

1 a Hojas palmatífidas o flabeliformes (Coryphoideae) .......... 2
b Hojas pinnadas o pinnado-partidas .......... 8
2 a Ovario apocarpico, unicarpelar, unilocular (Thrinaceae) .......... 3
b Ovario sincarpico, tricarpelar .......... 5
3 a Semillas sin surcos y fisuras .......... 4
b Semillas con surcos y fisuras .......... **3. Coccothrinax**
4 a Espádices paniculado-ramificadas, flores bracteadas, anteras con filamentos subulados, exertos .......... **1. Thrinax**
b Espádices 2-ramificados, flores sin bracteas, anteras sentadas a subsentadas .......... **2. Hemithrinax**
5 a Raquis de las hojas corto; carpelos $\pm$ separados (Livistoneae) .......... 6
b Raquis de las hojas largo; carpelos completamente unidos, ovario 3-locular (Sabaleae) .......... **7. Sabal**
6 a Pecíolos espinosos o ausentes .......... 7
b Pecíolos inermes; endospermo homogéneo .......... **5. Colpothrinax**
7 a Endospermo homogéneo .......... **4. Acoelorraphe**
b Endospermo ruminado .......... **6. Copernicia**
8 a Flores mas bien bisexuales en pequeños grupos en el extremo de las ramitas; flores femeninas pocas (Arecoideae, Pseudophoeniceae) .......... **8. Pseudophoenix**
b Todas las flores unisexuales .......... 9
9 a Flores en grupos lineares, 2–5-floros, las inferiores mayormente femeninas (Arecoideae, Chamaedoreae) .......... **9. Gaussia**
b Flores en triadas de una flor femenina y 2 masculinas en las ramitas, las masculinas a menudo en pares o solitarias distantes, o las flores femeninas en la porción inferior de las ramitas .......... 10
10 a Flores masculinas distantes en las triadas, o agregadas, no hundidas en el espádice 11
b Pétalos femeninos connados en un tubo; flores hundidos en alvéolos del espádice; flores masculinos proximos en las triadas (Geonomoideae) .......... **18. Calyptronoma**
11 a Fruto con endocarpio membranoso, fibroso o leñoso, sin poros (Arecoideae) .... 12
b Fruto con endocarpio óseo, con 3 poros (Cocosoideae) .......... 13
12 a Pétalos de las flores femeninas imbricados; endospermo ruminado (Euterpeae) .......... **10. Prestoea**
b Pétalos de las flores femeninas valvares, endospermo homogéneo (Roystoneae) .......... **11. Roystonea**
13 a Palmas inermes, poros cerca de la base del fruto (Cocoineae) .......... 14
b Palmas espinosas, poros en la mitad o cerca del ápice del fruto .......... 15
14 a Fruto grande, semilla 1; pétalos de la flor masculina oblongo-oblicuos ..... **12. Cocos**
b Fruto mediano, semillas 1–3; pétalos masculinos alargado-claviformes . **13. Scheelea**
15 a Poros cerca del ápice del fruto (Elaeineae) .......... **14. Elaeis**

b Poros en la parte media del fruto (Bactrineae) .............................. 17
16 a Flores femeninas en la parte inferior de las ramitas, pétalos imbricados, o todos connados ............................................................ 18
b Flores inferiores en triadas, pétalos femeninos connados ............... **17. Bactris**
17 a Tronco cilíndrico o subcilíndrico, leñoso y firme por dentro; sépalos de las flores de ambos sexos y pétalos femeninos libres, imbricados ................ **15. Acrocomia**
b Tronco fusiforme, pulposo y dulce por dentro; sépalos de las flores de ambos sexos y pétalos femeninos connados ................................ **16. Gastrococos**

## I. Subfamilia: CORYPHOIDEAE

### I.A. Tribus: *Trithrinaceae* (Trithrinax alliance H. E. Moore 1973)

### I.A.a. Subtribus: Thrinaceae (Thrinax unit H. E. Moore 1973)

*Fig. 1.* Thrinax radiata Lodd en el matorral esclerófilo costero («manigua costera») del Sur de Isla de Pinos (Foto: A. BORHIDI)

## 1. **THRINAX** Sw. Prodr. **4:** 57. 1788

1 a Vaina profundamente excisa en forma de V en el ápice; hojas verdes en ambas caras; flores y frutos con un pedicelo de 1–2 mm de largo .................. **1. T. radiata**
b Vaina lingüiforme en el ápice; hojas blancuzcas en el envés, mayormente con rayas de puntos blancos; flores y frutos subsentados a sésiles ............... **2. T. Morrisii**

1.1. **Thrinax radiata** Lodd. ex Schult. in Linn. Syst. Veg. sec. **7** (2): 1301. 1830.
(Syn.: *T. Wendlandiana* Becc. Webbia **2:** 285. 1907.; *T. parviflora* auct. e.g. Alain in Flora de Cuba Suppl. 29. 1969. non Sw.; *T. Martii* Griseb. et Wendl. ex Griseb. Cat. Pl. Cub. 1866: 221.)

1.2. **Thrinax Morrisii** Wendl. in Gard. Chron. (ser. 3.) **11:** 104 fig. 20. 21. 1892.
(Syn.: *T. microcarpa* Sarg. in Gard. For. **9:** 162. 1896.; *T. keyensis* Sarg. Bot. Gaz. **27:** 86. 1899.; *T. bahamensis* O. F. Cook in Northrop Mem. Torr. Bot. Cl. **12:** 20. 1902.; *T. Drudei* Becc. Webbia **2:** 269. 1907.; *T. punctulata* Becc. l.c. 280.)

## 2. **HEMITHRINAX** Hook. f. in Benth. et Hook. Gen. Plant. **3:** 930. 1883

1 a Fruto de 4–9 mm de diámetro; inflorescencias de 50–80 cm de largo (Sección *Hemithrinax*) ........................................................ 2
b Fruto de 13–15 mm de diámetro; inflorescencias de 150–200 cm de largo (Sección *Macrocarpae*) ............................................ **1. H. rivularis**
aa Palma de 6–8 m de alto, peciolo mas largo que la vaina ......... **var. rivularis**
bb Palma de 1–4 m de alto, peciolo igual o menos que la vaina .... **var. savannarum**
2 a Vaina con una capa gruesa de lana; limbo de la hoja orbicular de 120–140 cm de diámetro, con 60–70 segmentos .................................. **2. H. compacta**
b Vaina glabra con fibras gruesas; limbo de la hoja semiorbicular de 50 cm de diámetro, con 30–36 segmentos ...................................... **3. H. Ekmaniana**

Sectio*:* **Macrocarpae** (León) Muñiz
(Macrocarpae León in Mem. Soc. Cub. Hist. Nat. **15:** 383. 1941 sine indicat. taxonomica) Inflorescentiis elongatis, 1.5–2 mm longis, fructibus magnis, 13–15 mm in diametro.
Typus sectionis*: H. rivularis* León

2.1. **Hemithrinax rivularis** León Mem. Soc. Cub. Hist. Nat. **15:** 380. 1941.
2.1.1. **var. rivularis**
2.1.2. **var. savannarum** (León) Muñiz comb. n.
(Basionymon*: H. savannarum* León Mem. Soc. Cub. Hist. Nat. **15:** 381. 1941.)

Sectio*:* **Hemithrinax**
(Microcarpae León l. c. 383. 1941.) Inflorescentiis usque ad 70 cm longis, fructibus parvis, 4–9 mm in diametro.

2.2. **Hemithrinax compacta** (Griseb. et Wendl.) Hook. f. in Benth. et Hook. Gen. Plant. **3:** 931. 1883.
(Syn.: Trithrinax compacta Griseb. et Wendl. ex Griseb. Cat. Pl. Cub. 1966: 221.)

2.3. **Hemithrinax Ekmaniana** Burret in Kungl. Svensk. Vet.-Akad. Handl. **6** (7): 9. 1929.
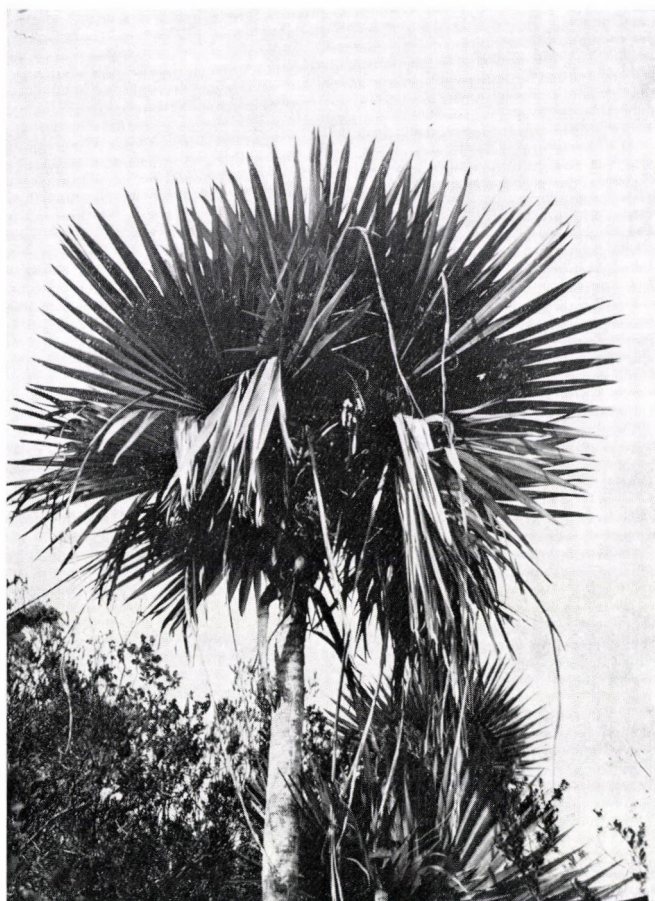
*Fig. 2.* Hemithrinax rivularis var. savannarum (León) Muñiz en el matorral siempreverde subhúmedo de serpentinas (Charrascal) del Cerro de Miraflores, Moa. (Foto: A. Borhidi)

## 3. COCCOTHRINAX Sarg. in Bot. Gaz. **27:** 87. 1899

1 a Inflorescencias alargadas y ascendentes a veces encorvadas en el ápice raquis de las inflorescencias parciales recto, espatas externas rígidas (Sección *Longispadiceae*) .. 2
b Inflorescencias breves, colgantes o encorvadas a la madurez del fruto, raquis de las inflorescencias parciales encorvadas; espatas externas en parte membranosas (**Sección** *Coccothrinax*) .......... 13
2 a Palmas robustas, inflorescencias parciales 8–10, muy ramificadas (Subsección *Longispadiceae*) .......... 3
b Palmas pequeñas, delgadas, inflorescencias parciales 1–7 poco ramificadas (Subsección *Pauciramosae*) .......... 5
3 a Porción libre de la vaina de fibras alargadas y filiformes en toda su longitud. Envés de las hojas verdes; pedicelos gruesos y cortos, frutos de hasta 20 mm de diámetro .......... **1. C. crinita**

aa fibras libres de la vaina de igual largo de la vaina o mucho más; hojas nitidas y glandulosas en el envés ........................................ **ssp. crinita**
bb fibras libres de la vaina más cortas que la vaina, hojas ferrugineo-tomentosas a glabrescentes en el envés, los puntos cubiertos por el indumento ... **ssp. brevicrinis**
b Porción libre de la vaina redondeada o trapeziforme formada por fibras rígidas. Envés de las hojas plateados. Pedicelos delgados; frutos de hasta 12–13 mm de diámetro 4
4 a Fibras de la vaina de 3–4 mm de ancho terminando en puntas libres de 4–6 cm de largo. Ligula 1 en el haz. Hojas orbiculares, segmentos centrales de ±90 cm de largo, dos veces ensanchados, puntas de 4–6 cm, puntos pálidos inconspicuos en el envés ............................................................. **2. C. Gundlachii**
b Fibras de la vaina de 1–2 mm de ancho, puntas libres de 1–3 cm de largo. Ligula doble en ambas caras. Hojas 1/2–3/4-orbiculares, segmentos centrales de 60–70 cm, largamente acuminados, puntas de 30–35 cm de largo. Puntos glanduliformes prominulos en el envés .................................................. **3. C. camagüeyana**
5 a Porción libre de la vaina de fibras alargadas y filiformes en toda su longitud; pecíolo de hasta 10–15 cm de largo ..................................... **4. C. Borhidiana**
b Porción libre de la vaina entera o terminada en puntas libres rígidas, pecíolo de más largo de 15 cm ........................................................... 6
6 a Vaina entera, no terminada en puntas libres ................................ 7
b Vaina terminada en puntas libres rígidas .................................... 8
7 a Hojas concolores, sin puntos glanduliformes en el envés, frutos de 7×9 mm de diám. sentados .................................................... **5. C. rigida**
b Hojas plateadas en el envés con muchos puntos diminutos fuscos, frutos de 9–10× 11–12 mm de diámetro, con pedicelos de 0.5–2 mm de largo ...... **6. C. baracoensis**
8 a Hojas con 25–35 segmentos ........................................... 9
b Hojas con 10–20 segmentos ........................................... 11
9 a Hojas con puntos glandulosos fuscos numerosos en el envés, indumento nulo ....... ............................................................. **7. C. Garciana**
b Hojas con puntos glandulosos pálidos o ferruginosos y con un indumento ferrugineo a plateado en el envés ................................................ 10
10 a Inflorescencias parciales 4–7, frutos de 9×12 mm de diámetro ...... **8. C. clarensis**
aa Segmentos centrales de 50–60 cm de largo con puntas de 25–32 cm de largo y 4–5 cm de ancho, indumento ferruginoso ........................ **ssp. clarensis**
bb Segmentos centrales de las hojas de 30–40 cm de largo, con puntas de 6–10 cm de largo, el envés glabrescente ................................ **ssp. brevifolia**
b Inflorescencias parciales 1–3, frutos de 5–7 mm de diámetro ...... **9. C. savannarum**
11 a Puntas libres de la vaina de 1–2 mm de ancho, segmentos centrales de las hojas muy brevemente (0.8–1.5 cm) connados con puntos glandulosos fuscos numerosos en el envés. Ramitas de las inflorescencias parciales 6–9 ............ **10. C. pauciramosa**
b Puntas libres de la vaina de 3–5 mm de ancho, segmentos centrales de la hoja hasta 3–4 cm connados con puntos pálidos o fuscos escasos en el envés. Ramitas de las inflorescencias parciales 10–14 ........................................... 12
12 a Segmentos de las hojas revolutos, lustrosos en el haz, con puntos pálidos en el envés. Flores y frutos pedicelados ................................ **11. C. pseudorigida**
b Segmentos de las hojas planos no lustrosos en el haz, con puntos fuscos en el envés. Flores y frutos sentados sobre un disco grueso ................. **12. C. nipensis**
13 a Ovario densamente apendiculado-muricado (Subsección *Haitiella*), hojas pequeñas, plateadas, triangular 1/3-orbiculares cuneadas en la base con 16–20 segmentos ...... ............................................................. **13. C. Munizii**
b Ovario no apendiculado-muricado (Subsección *Coccothrinax*) .................. 14

14 a Hojas no plateadas y con un indumento blancuzco caedizo en el envés .......... 15
b Hojas plateadas en el envés, el indumento no caedizo ........................ 23
15 a Hojas sin puntos en el envés, lígula trilobulada con una punta aguda central; segmentos 45–65 ........................................................ 16
b Hojas con puntos en el envés; lígula no trilobulada, segmentos 20–50 ........... 17
16 a Vaina formada de fibras finas compuestas y débiles, flores subsentadas ............ ........................................................ **14. C. Hiorami**
b Vaina formada de fibras sencillas coriáceas, flores pediceladas ... **15. C. guantanamensis**
17 a Vainas densamente entretejidas de fibras finas ............................. 18
b Vainas laxamente entretejidas de fibras gruesas ............................ 19
18 a Porción libre de la vaina de 15–20 cm de largo, lingüiforme, dorsalmente abullonada; inflorescencias parciales aproximadas, estambres 9 ................ **16. C. Victorini**
b Porción libre de la vaina muy corta o nula, truncada; inflorescencias parciales distantes, estambres 12 ............................................. **17. C. fragrans**
19 a Hojas con 25–45 segmentos, unidos en 5–40 cm de largo en la base ............. 20
b Hojas con 15–25 segmentos, los centrales hasta de 25 cm de largo, unidos en 2–4 cm de largo en la base ...................................................... 22
20 a Segmentos de 40–45; filamentos connados hasta la mitad del ovario .. **18. C. Acuñana**
b Segmentos de las hojas 25–35, filamentos connados sólo en la base ............. 21
21 a Vaina redondeada, sin puntas libres; segmentos de las hojas obtusos y redondeados en el ápice, con puntos pequeños fuscos en el envés. Fruto liso ..... **19. C. orientalis**
b Vaina con puntas libres de 1–2 mm de ancho; segmentos de las hojas agudas en el ápice, el envés nítido, estriado-nervoso con puntos pálidos salientes; fruto muricado ........................................................ **20. C. muricata**
22 a Vaina redondeada, sin puntas libres; limbo de la hoja orbicular, flores y frutos con pedicelos de 1–2 mm de largo, estambres 9 ...................... **21. C. moaensis**
b Vaina con puntas libres de 1 mm de ancho y 3–4 cm de largo, limbo de la hoja 1/3-orbicular, cuneada en la base, flores y frutos sentados, estambres 6–8 ............ ........................................................ **22. C. microphylla**
23 a Hojas sin puntos en el envés, frutos pequeños, sentados .............. **23. C. Leonis**
b Hojas punteadas en el envés, frutos mayormente pedicelados ................... 24
24 a Inflorescencias parciales 4–6, algo distantes ............................... 25
b Inflorescencias parciales 1–4, aproximadas ................................ 26
25 a Vaina de la hoja densamente entretejida de fibras finas, comunmente de menos de 1 mm de ancho; hojas con 40–45 segmentos ..................... **24. C. litoralis**
b Vaina laxamente entretejida de fibras gruesas de 1–4 mm de ancho; hojas con 25–32 segmentos ................................................. **25. C. saxicola**
26 a Porción libre de la vaina terminada en haces fibrosos con puntas libres ......... 27
b Porción libre de la vaina con fibras entretejidas hasta el borde, sin puntas libres .. 29
27 a Puntas libres de la vaina de 1–2 mm de ancho, flexibles y quebradizas; segmentos de las hojas 40–50, largamente estrechadas en una punta aguda; ligula triangular de hasta 3.5 cm de largo ............................................ **26. C. macroglossa**
b Puntas libres de la vaina de 3–9 mm de ancho, muy rígidas; segmentos de las hojas 35–42, bruscamente estrechados en un ápice ancho, ligula corta ................ 28
28 a Puntas libres de la vaina de 3–4 mm de ancho, agudas en el ápice; segmentos centrales de 40–50 cm de largo, hasta 4.5 cm de ancho, con puntos pequeños fuscos en el envés. Inflorescencias parciales cortas; flores subsésiles, pedicelos de hasta 1 mm de largo; estambres 6–7, filamentos soldados hasta la base ................ **27. C. yunquensis**
b Puntas libres de la vaina de 4–9 mm de ancho, obtusas en el ápice; segmentos centrales de 30–40 cm de largo y hasta 6 cm de ancho, con puntos glánduliformes grandes y

pálidos en el envés. Flores con pedicelos de 1–2.5 mm de largo; estambres 7–9, mayormente connados hasta la mitad, formando una cupula ........... **28. C. salvatoris**

aa Puntas libres de la vaina de hasta 6 mm de ancho, filamentos unidos casi hasta la mitad ................................................ **ssp. salvatoris**

bb Puntas libres de la vaina de hasta 9 mm de ancho, filamentos unidos sólo en la base ................................................ **ssp. loricata**

29 a Hojas de la planta adulta con 40–60 segmentos; pedicelos comunmente de 3–6 mm de largo ................................................ **34. C. Miraguama**

b Hojas de las plantas adultas con menos de 40 segmentos; comunmente con 20–36; pedicelos de 0–3 mm de largo ................................................ 30

30 a Segmentos del periantio estrechamente subulados, mucho mas estrechos que la porción basal de los filamentos y comunmente menos de la mitad de su longitud; pedicelos de 2–3 mm de largo ................................................ 31

b Segmentos del periantio anchos y casi tan largos como los filamentos; pedicelos de 0–2 mm de largo ................................................ 32

31 a Hojas con 24–30 segmentos, los centrales de 28–32 cm de largo, agudos en el ápice, connados en 4–7 cm de largo en la base ........................ **29. C. yuraguana**

b Hojas con 30–36 segmentos, los centrales de 45–50 cm de largo, unidos en 12–15 cm de largo en la base, filamentos connados en una cupula de 1/3–1/2 de su longitud ................................................ **30. C. cupularis**

32 a Segmentos de las hojas 18–25, de 2–3.5 cm de ancho, fruto de 4–5 mm de diámetro ................................................ **31. C. elegans**

b Hojas con 25–40 segmentos de 3.5–6.5 cm de ancho; fruto de 5–10 mm de diámetro ................................................ 33

33 a Vainas de fibras de 1–2 mm de ancho, truncada en el ápice; hojas con 35–40 segmentos; limbo plateado en el envés con puntos glanduliformes pálidos a blancos; fruto de 5–8 mm de diámetro ........................................ **32. C. Alexandri**

aa Hojas ± mates en el haz, fruto 5–6 mm de diámetro ........... **ssp. Alexandri**

bb Hojas lustrosas en el haz, fruto de 7–8 mm de diámetro ............. **ssp. nitida**

b Vaina de fibras de 1 mm de ancho, la parte libre aovada; hojas con 25–30 segmentos, el envés con puntos pequeños fuscos; fruto de 9–10 mm de diámetro .............. ................................................ **33. C. Bermudezii**

Sectio: **Longispadiceae** (León) Muñiz status nov.
(Basionymon: Series *Longispadiceae* León Mem. Soc. Cub. Hist. Nat. **13:** 110. 1939. sine descr. latina.) Inflorescentiis elongatis et ascendentibus, spathis externis rigidis.
Typus sectionis: *Coccothrinax rigida* (Griseb. et Wendl.) Becc.
Subsectio: **Multiramosae** León ex Muñiz
(*Multiramosae* León l.c. sine indicatione taxonomica) Palmae robustae caudice crasso. Inflorescentiis partialibus 8–10, valde ramificatis.
Typus subsectionis: *Coccothrinax gundlachii* León.

3.1. **Coccothrinax crinita** (Griseb. et Wendl.) Becc. Webbia **2:** 334 (1907).
(Basionymon: *Thrinax crinita* Griseb. et Wendl. in Sauvalle Anal. Acad. Cien. Habana **7:** 563. 1971.)

3.1.1. ssp. **crinita**

*Fig. 3.* Coccothrinax camagüeyana Borhidi et Muñiz en las sabanas serpentinosas al Sur de Minas. (Foto: A. BORHIDI)

3.1.2. ssp. **brevicrinis** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 448. (1981) 1982.

3.2. **Coccothrinax Gundlachii** León Mem. Soc. Cub. Hist. Nat. **13:** 149 (1939).

3.3. **Coccothrinax camagüeyana** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 441. (1981) 1982.

Subsectio: **Pauciramosae** León ex Muñiz
(*Pauciramosae* León l.c. 110. sine indicatione taxonomica) Palmae medianae vel parvae, caudice tenui, inflorescentiis partialibus 1–7.

3.4. **Coccothrinax Borhidiana** Muñiz in Borhidi, Imchanitzkaya et Muñiz Acta Agronom. Acad. Sci. Hung. **27:** 437 (1978).

3.5. **Coccothrinax rigida** (Griseb. et Wendl.) Becc. Webbia **2:** 299 (1907).
(Basionymon: *Thrinax rigida* Griseb. et Wendl. in Griseb. Cat. Plant. Cub. 1866: 221.)

3.6. **Coccothrinax baracoënsis** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 440. (1981) 1982.

3.7. **Coccothrinax Garciana** León l.c. 143. (1939).

3.8. **Coccothrinax clarensis** León l.c. 147. (1939).
(Syn.: *C. clarensis* var. *perrigida* León l.c. 149. 1939.)

3.8.1. ssp. **clarensis**

3.8.2. ssp. **brevifolia** (León) Borhidi et Muñiz **status nov.**
(Basionymon: *C. clarensis* León var. *brevifolia* León Mem. Soc. Cub. Hist. Nat. **13:** 148. 1939.

*Fig. 4.* Coccothrinax Borhidiana Muñiz en el matorral esclerófilo costero del Punta de Guano, al Oeste de Matanzas. (Foto: A. BORHIDI)

3.9. **Coccothrinax savannarum** (León) Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 452. (1981) 1982.
(Basionymon: *Coccothrinax muricata* León var. *savannarum* León l.c. 129. 1939.)

3.10. **Coccothrinax pauciramosa** Burett Kungl. Svensk. Vet. Akad. Handl. **6** (7): 19. 1929.

3.11. **Coccothrinax pseudorigida** León l.c. 145. 1939.
(Syn.: *C. pseudorigida* var. *acaulis* León l.c. 146.)

3.12. **Coccothrinax nipensis** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 446. (1981) 1982.

Sectio: **Coccothrinax**

(Syn.: Series *Brevispadiceae* León l.c. 110. 1939. sine descr. latina) Spadicibus brevibus cernuis vel nutantibus sub maturitate fructi; inflorescentiis partialibus 1–6, spathis externis pro parte membranaceis.

*Fig. 5.* Coccothrinax Munizii Borhidi en la zona semidesertica de la costa Sur de Baracoa, entre San Antonio del Sur e Imias. (Foto: A. Borhidi)

Typus sectionis: *Coccothrinax jucunda* Sarg.
Subsectio: **Haitiella** (Bailey) Muñiz comb. nova
(Basionymon: *Haitiella* Bailey Contr. Gray Herb. Harvard Univ. **165:** 7. 1947. pro gen.)
Ovario atque fructibus valde densiterque muricatis, seminibus albumine homogeneo. Typus subsectionis: *Coccothrinax Ekmanii* Burret.

3.13. **Coccothrinax Munizii** Borhidi Acta Bot. Acad. Sci. Hung. **17:** 1. 1971.
[Syn.: *Haitiella Munizii* (Borhidi) Borhidi Acta Bot. Acad. Sci. Hung. **25:** 2. 1979.]

Subsectio: **Coccothrinax**
Ovario atque fructibus non vel sparse muricatis, seminibus albumine ruminato.

*Fig. 6.* Coccothrinax moaensis (Borhidi et Muñiz) Muñiz en los matorrales siempreverdes montanos de serpentina en la Sierra de Maguey, Cupeyal, NE de Guantánamo. (Foto: A. Borhidi)

3.14. **Coccothrinax Hiorami** León Mem. Soc. Cub. Hist. Nat. **13:** 135. 1939.

3.15. **Coccothrinax guantanamensis** (León) Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 449. (1981) 1982.
[Basionymon: *Coccothrinax argentea* (Lodd.) Sarg. var. *guantanamensis* León l.c. 135. 1939. — Syn.: *C. argentea* ssp. *guantanamensis* (León) Borhidi et Muñiz Bot. Közlem. **58:** 176. 1971.]

3.16. **Coccothrinax Victorini** León l.c. 139. 1939.

3.17. **Coccothrinax fragrans** Burret Kungl. Svensk. Vet. Akad. Handl. **6** (7): 15. 1929.

3.18. **Coccothrinax Acunana** León l.c. 128. 1939.

3.19. **Coccothrinax orientalis** (León) Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 451. (1981) 1982.
[Basionymon: *Coccothrinax yuraguana* (A. Rich.) León var. *orientalis* León Mem. Soc. Cub. Hist. Nat. **13:** 121. 1939. — Syn.: *C. yuraguana* ssp. *orientalis* (León) Borhidi Acta Bot. Acad. Sci. Hung. **17: 2.** 1971.]

*Fig. 7.* Coccothrinax elegans Muñiz et Borhidi en el bosque de carso de los Mogotes de la Sierra Maestra, cerca de Matias. (Foto: A. BORHIDI)

3.20. **Coccothrinax muricata** León l.c. 129. 1939.

3.21. **Coccothrinax moaensis** (Borhidi et Muñiz) Muñiz Acta Bot. Acad. Sci. Hung. **27:** 451. (1981) 1982.
[Basionymon: *Coccothrinax yuraguana* (A. Rich.) León ssp. *moaensis* Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **17: 1.** 1971.]

3.22. **Coccothrinax microphylla** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 444. (1981) 1982.

3.23. **Coccothrinax Leonis** Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 443. (1981) 1982.

3.24. **Coccothrinax litoralis** León Mem. Soc. Cub. Hist. Nat. **13:** 138. 1939.

3.25. **Coccothrinax saxicola** León l.c. 141. 1939.

3.26. **Coccothrinax macroglossa** (León) Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 450. (1981) 1982.
[Basionymon: *Coccothrinax Miraguama* (HBK.) Becc. var. *macroglossa* León Mem. Soc. Cub. Hist. Nat. **13:** 118. 1939. — Syn.: *C. Miraguama* ssp. *macroglossa* (León) Borhidi et Muñiz Bot. Közlem. **58:** 175. 1971.]

3.27. **Coccothrinax yunquensis** Borhidi et Muñiz Acta Bot. Acad. Sci. Hung. **27:** 446. (1981) 1982.

3.28. **Coccothrinax salvatoris** León l.c. 125. 1939.

3.28.1. ssp. **salvatoris**

*Fig. 8.* Coccothrinax Miraguama ssp. miraguama en los matorrales costeros sobre caliza cerca de Baracoa. (Foto: A. Borhidi)

3.28.2. ssp. **loricata** (León) Borhidi et Muñiz Bot. Közlem. **58:** 175. 1971.
(Basionymon: *C. salvatoris* var. *loricata* León l.c. 127. 1939.)

3.29. **Coccothrinax yuraguana** (A. Rich.) León Mem. Soc. Cub. Hist. Nat. **13:** 119. 1939.
(Basionymon: *Thrinax yuraguana* A. Rich. in Sagra: Hist. Fis. Nat. Pol. Cuba. XI: 278. 1850. — Syn.: *Coccothrinax Miraguano* Beccari Webbia **2:** 295. 1907. non *Corypha Miraguama* HBK.)

3.30. **Coccothrinax cupularis** (León) Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 449. (1981) 1982.
[Basionymon: *Coccothrinax miraguama* (HBK.) León var. *cupularis* León l.c. 11. 1939.]

3.31. **Coccothrinax elegans** Muñiz et Borhidi Acta Bot. Acad. Sci. Hung. **27:** 442. (1981) 1982.

3.32. **Coccothrinax Alexandri** León Mem. Soc. Cub. Hist. Nat. **13:** 122. 1939.

3.32.1. ssp. **Alexandri**

3.32.2. ssp. **nitida** (León) Borhidi et Muñiz Bot. Közlem. **58:** 175. 1971.
(Basionymon: *C. alexandri* var. *nitida* León l.c. 123. 1939.)

*Fig. 9.* Acoelorraphe Wrightii (Griseb. et Wendl.) Wendl. ex Becc. en los matorrales de pantano, en la Ciénaga de Zapata. (Foto: A. BORHIDI)

3.33. **Coccothrinax Bermudezii** León l.c. 124. 1939.

3.34. **Coccothrinax Miraguama** (HBK.) León Mem. Soc. Cub. Hist. Nat. **13:** 113. 1939. [Syn.: *Corypha Miraguama* HBK. Nov. Gen. et Spec. 239. 1815. non *C. Miraguano* Becc. in Webbia **2:** 295. 1907.; *Thrinax Miraguano* Mart. Hist. Nat. Palm. **3:** 320. 1838.; *Thrinax acuminata* Griseb. et Wendl. In Sauvalle Anal. Acad. Cien. Habana **7:** 563. 1871.; *Coccothrinax acuminata* (Griseb. et Wendl.) Sarg. ex Becc. Webbia **2:** 313. 1907.]

3.34.1. ssp. **Miraguama**

3.34.2. ssp. **arenicola** (León) Borhidi et Muñiz Bot. Közlem. **58:** 175. 1971. (Syn.: *C. Miraguama* var. *arenicola* León l.c. 115. 1939.)

3.34.3. ssp. **havanensis** (León) Borhidi et Muñiz l.c. 175. 1971. (Syn.: *C. Miraguama* var. *havanensis* León l.c. 116. 1939.)

3.34.4. ssp. **roseocarpa** (León) Borhidi et Muñiz l.c. 175. 1971. (Syn.: *C. Miraguama* var. *roseocarpa* León l.c. 117. 1939.)

## I.B. Tribus: *Livistoneae* (Livistona alliance H. E. Moore 1973)

## I.B.a. Subtribus: Livistoneae (Livistona unit H. E. Moore 1973)

## 4. **ACOELORRAPHE** Wendl. in Bot. Zeitschr. 1879: 148

(Syn.: *Paurotis* O. F. Cook ex Northrop in Mem. Torr. Bot. Cl. **12:** 21. 1902.; *Acanthosabal* Prschow. Gard. Chron. ser. 3. **77:** 91. 1925.)

4.1. **Acoelorraphe Wrightii** (Griseb. et Wendl.) Wendl. ex Becc. Webbia **2:** 109. 1907. (Syn.: *Copernicia Wrightii* Griseb. et Wendl. ex Griseb. Cat. Pl. Cub. 1866: 220.; *Paurotis Wrightii* Britt. Torreya **8:** 239. 1908.; *Acanthosabal caespitosa* Proschowsky l.v. 91. 1925.; *Acoelorraphe Wrightii* var. *nova-geronensis* Becc. Webbia **2:** 113. 1907.)

*Fig. 10.* Colpothrinax Wrightii Griseb. et Wendl. en las sabanas arenosas del Sur de Pinar del Rio, cerca del Consolación del Sur. (Foto: A. Borhidi)

## 5. **COLPOTHRINAX** Griseb. et Wendl. Bot. Zeitschr. 1879: 147

5.1. **Colpothrinax Wrightii** Griseb. et Wendl. in Pl. Cub. Wright. [Syn.: *Pritchardia Wrightii* (Griseb. et Wendl.) Becc. l.c. 203. 1907.]
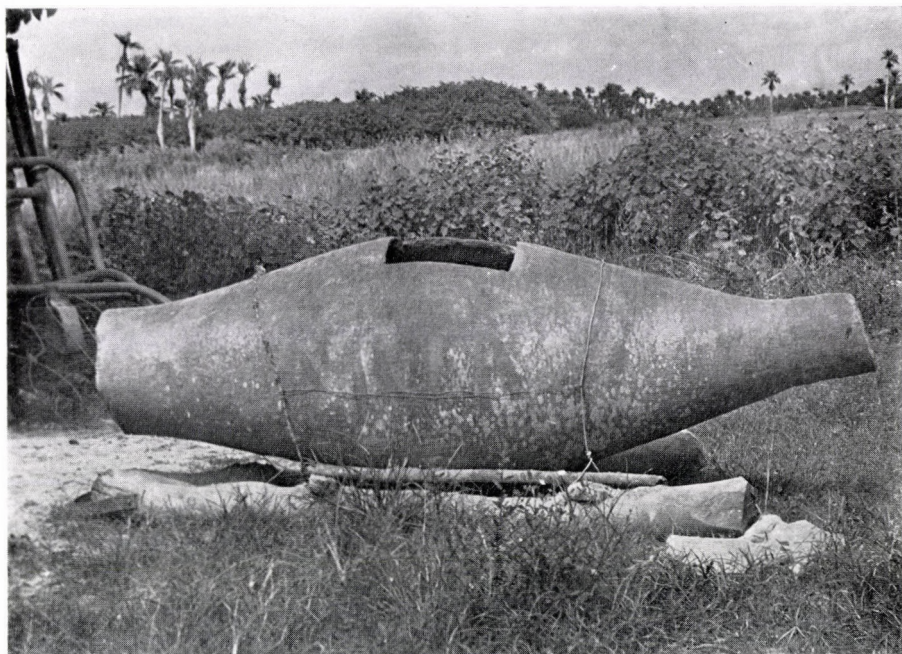
*Fig. 11.* Barril campesino hecho del tronco de Colpothrinax wrightii. (Foto: A. BORHIDI)

## 6. **COPERNICIA** Martius Hist. Nat. Palm. **3:** 242. 1838

Clave para las secciones:

1 a Ramitas floríferas sin espatela tubulosa, solo con una bráctea en la base (Subgénero: *Copernicia*) ........ 2
b Ramitas floríferas con una espatela tubulosa (Subgénero: *Coperniciopsis*) ........ 4
2 a Limbo de las hojas orbiculares o semiorbiculares, lígula de 3–5 cm de largo ..... 3
b Limbo de las hojas cuneadas en la base, lígula de hasta 12 (18) cm de largo ........ III. Sectio: **Gigantes**
3 a Flores en fascículos 2–4-floros ........ I. Sectio: **Copernicia**
b Flores solitarias ........ II. Sectio: **Ekmanianae**
4 a Palmas robustas, tronco de 30–80 cm de diámetro, pecíolo robusto de 3.5–9 cm de ancho en el ápice ........ VII. Sectio: **Yareyes**
aa Flores en fasciculos ........ VII.a. Subsectio: **Yareyes**
bb Flores solitarias ........ VII.b. Subsectio: **Fallaenses**
b Palmas mediocres o pequeñas con tronco de hasta 25 cm de diámetro, pecíolo de 1–3.5 cm de ancho en el ápice ........ 5
5 a Ramitas floríferas de 0.5–2 cm de largo, flores solitarias ........ 6
b Ramitas floríferas de 2–10 cm de largo, flores mayormente en fasciculos ........ 7
6 a Hojas cuneiformes o semiorbiculares, pecíolo ausente o muy corto ........ IV. Sectio: **Macroglossae**
b Hojas orbiculares, pecíolo mas largo de 50 cm ........ IX. Sectio: **Hospitae**

7 a Hojas orbiculares, anillo estaminal con 6 lóbulos iguales ..................... 8
b Hojas cuneiformes a semiorbiculares, anillo estaminal con 3 + 3 lóbulos desiguales (cuando iguales, las hojas cuneiformes) .................................... 9
8 a Flores en fasciculos 2–4-floros, filamentos largos, ensanchados en la base, ovario hirsuto arriba, ramitas fructíferas no engrosadas .................. VI. Sectio: **Albae**
b Flores en grupos 1–2-floros, filamentos cortos, ovario glabro, ramitas fructíferas irregularmente engrosadas ............................ VIII.b. Subsectio: **Roigianae**
9 a Limbo de las hojas cuneiformes, pecíolo ausente o corto (hasta 30 cm) muy ancho (hasta 9 cm) en el ápice, anillo estaminal con 6 lóbulos iguales .. VII. Sectio: **Rigidae**
b Limbo de las hojas semiorbiculares a orbiculares con pecíolo mayormente mas largo (mas corto en C. Cowellii) y mas estrecho (hasta 3 cm) en el ápice (hasta 6 cm en C. Molineti). Anillo estaminal con lóbulos 3 + 3, desiguales .........................
........................... VIII. Sectio: **Brittonianae**, a. Subsectio: **Brittonianae**

## Clave para las espécies cubanas:

1 a Ramitas floríferas o fructíferas sin espatela tubulosa, solo con una bráctea en la base; palmas de 15–20 m de altura, tronco de 30–50 cm de grueso, hojas cuneiformes ......
.............................................................. **1. C. gigas**
b Ramitas floríferas o fructíferas sostenidas por una espatela tubulosa; palmas mayormente mas pequeñas; cuando robustas, las hojas orbiculares .................. 2
2 a Limbo de la hoja cuneiforme o semiorbicular ..................................... 3
b Limbo de la hoja orbicular ............................................... 9
3 a Hojas verdes, no cerosas; flores solitarias ....................................... 4
b Hojas cerosas; flores en glomérulos .............................................. 5
4 a Pecíolo ausente, ramitas floríferas de 8–20 mm de diámetro flores de 5–8 mm de largo, bracteolas de 5–7 mm de largo ........................... **2. C. macroglossa**
b Pecíolo de 20–30 cm de largo, ramitas floríferas de 3–8 mm de diámetro, flores de 4–5 mm de largo, bracteolas de 2–4 mm de largo ............. **18. C. × Burretiana**
5 a Pecíolo ausente .......................................................... 6
b Pecíolo de 15–20 cm de largo .............................................. 7
6 a Ramitas floríferas hasta 5 cm de largo, 1–2 mm de diámetro; hojas con 18–32 segmentos
.............................................................. **3. C. rigida**
b Ramitas floríferas de hasta 8 cm de largo, 2–2.5 mm de diámetro, hojas con unos 42 segmentos ................................................ **4. C. longiglossa**
7 a Ramitas floríferas de 6–11 cm de largo, algunas de ellas sin espatelas tubulares; pecíolo casi tan ancho en la base, como largo ..................... **19. C. × vespertilionum**
b Ramitas floríferas de menos de 6 cm de largo, mayormente todas con espatelas tubuliformes; pecíolo comunmente mas largo como ancho en la base ................ 8
8 a Ramitas floríferas de 3–5.5 cm de largo, 2.5–3.5 mm de diámetro; glomérulos de las flores separados en 1–2 mm; hojas con 40–50 segmentos ............ **5. C. oxycalyx**
b Ramitas floríferas de 2–3 cm de largo, 1.5–2.5 mm de diámetro; glomérulos de las flores separados en 0.5–1 mm; hojas con 21–30 segmentos ......... **20. C. × Sueroana**
9 a Tronco elevado y grueso de 30–80 cm de diámetro, pecíolo robusto de 3.5–9 cm de ancho en el ápice ............................................... 10
b Tronco de hasta 25 cm de diámetro; pecíolo de 1–3.5 cm de ancho en el ápice ... 12
10 a Ramitas de las panojas de 0.5–3 mm de diámetro; hojas con 70–90 segmentos, ramitas fructíferas irregularmente engrosadas ............................ **6. C. Curbeloi**
b Ramitas de las panojas de 3–4 mm de diámetro, hojas con 100–130 segmentos; ramitas fructíferas no engrosadas irregularmente ................................ 11

11 a Ramitas de las panojas de hasta 8 cm de largo; flores en glomérulos 2–3-flores; las brácteas florales suaves, reflejas en el fruto ...................... **7. C. Baileyana**
b Ramitas de las panojas de hasta 3.5 cm de largo, flores solitarias, bracteolas florales rígidas, horizontales en el fruto ............................. **8. C. fallaensis**
12 a Flores comunmente en glomérulos de 2–4 ................................ 13
b Flores comunmente solitarias ........................................... 21
13 a Ramitas fructíferas no engrosadas irregularmente; flores mayormente en glomérulos de 2–4; anillo estaminal con 3 + 3 lóbulos desiguales ........................ 14
b Ramitas fructíferas por lo comun irregularmente engrosadas; flores en grupos de 2; anillo estaminal con 6 lóbulos iguales ................................ 20
14 a Flores de 4–6 mm de largo ............................................ 15
b Flores de 2.5–4 mm de largo ........................................... 17
15 a Ramitas fructíferas de 2–3 mm de diámetro; limbo de las hojas de hasta 130 cm de largo ................................................... **21. C.×textilis**
b Ramitas fructíferas de 1–2 mm de diámetro; limbo de las hojas de hasta 90 cm de largo ......................................................... 16
16 a Ramitas floríferas de 3–4 cm de largo, con 12–14 flores por cm; hojas densamente cerosas en el envés ............................................. **9. C. Cowellii**
b Ramitas floríferas de 1.5–3 cm de largo, con 18–20 flores por cm; hojas densamente cerosas en ambas caras .................................... **22. C.×Shaferi**
17 a Hojas densamente cerosas, puntos glanduliformes (stegmata) comunmente prominentes, ramitas floríferas no blancuzcas ......................................... 18
b Hojas no cerosas o solo con una capa ligera de cera; los stegmata inconspicuos o ausentes; ramitas floríferas blancuzcas o amarillentas ......................... 19
18 a Ramitas fructíferas más anchas cerca de la base, con bracteolas horizontales, persistentes ................................................... **10. C. humicola**
b Ramitas fructíferas más o menos fusiformes; bracteolas comunmente deciduas ....... ............................................................ **11. C. Molineti**
19 a Ramitas de panojas de 4–5 cm de largo; flores en grupos de 2–4, hojas con 55–65 segmentos ............................................... **12. C. Brittonorum**
b Ramitas de panojas de 0.5–2 cm de largo; flores en grupos de 2, a veces solitarias; hojas con unos 78 segmentos ............................ **23. C.×occidentalis**
20 a Ramitas floríferas de 1–2 mm de diámetro, 1–3.5 cm de largo ......... **13. C. Yarey**
aa Ramitas floríferas de 2–3.5 cm de largo, 1–1.5 mm de diámetro; glomérulos de las flores separados en 1–2 mm, con 14–16 flores por cm ................. **var. Yarey**
ab Ramitas floríferas de 1–2.5 cm de largo, 1–2 mm de diámetro; glomérulos de las flores separados en 0.5–1 mm con 18–22 flores por cm ............. **var. robusta**
b Ramitas floríferas de 0.5–1 mm de diámetro, 0.5–1.2 cm de largo, flores a veces solitarias ..................................................... **14. C. Roigii**
21 a Ramitas floríferas y bracteolas florales glabros o pruinosos; flores de 2.5–3.5 mm de largo ................................................. **15. C. glabrescens**
aa Ramitas floriferas de 3–10 mm de largo, con 11–20 flores por cm; pétalos densamente corto-pubérulos a pulverulentos por fuera ............... **var. glabrescens**
ab Ramitas floríferas de 7–15 mm de largo, con 6–10 flores por cm; pétalos completamente glabros y pruinosos por fuera ......................... **var. ramosissima**
b Ramitas floríferas y bracteolas florales densamente pubescentes; flores de 3.5–5 mm de largo ....................................................... 22
22 a Hojas densamente cerosas en ambas caras; stegmata prominentes en el envés; ramitas floríferas de 1.5–2.5 mm de ancho, flores de 4–5 mm de largo ........ **16. C. hospita**
b Hojas mayormente verdes sin cera; stegmata ausentes o inconspicuos en el envés;

ramitas floríferas de hasta 1 mm de ancho, flores de 3.5–4 mm de largo ........... ........................................................ **17. C. Curtissii**

Subgenus: **Copernicia**
Rami floriferi sine spathis tubulosis, solummodo cum bractea una basali suffulti.
I. Sectio: **Copernicia**
Limbus folii orbicularis, ligula usque ad 4–5 cm longa, floribus 2–4 fasciculatis (*C. cerifera*, *C. Berteroana*)
II. Sectio: **Ekmanianae** Muñiz **sect. n.**
Limbus folii orbicularis vel semiorbicularis, ligula 3–5 cm longa, floribus solitariis.
Typus sectionis: *Corypha tectorum* HBK. (*Copernicia tectorum*, *C. Ekmanii*).
III. Sectio: **Gigantes** León em. Muñiz
(Syn.: *Gigantes* León in Rev. Soc. Geogr. Cub. **4:** 6. 1931. descr. incompleta.)
Limbus folii cuneiformis, ligula usque ad 12(–18) cm longa, floribus in fasciculis 2–3-floris.
Typus sectionis: *C. gigas* Ekm. ex Burret.

6.1. **Copernicia gigas** Ekman ex Burret Kungl. Svensk. Vet.-Akad. Handl. ser. 3. **6** (7): 3. 1929.
(Syn.: *C. excelsa* León Rev. Soc. Geogr. Cub. **4:** 56. 1931.)

Subgenus: **Coperniciopsis** Becc. Webbia **2:** 140. 1907.
Ramuli floriferi plerumque spathis tubulosis basalibus suffulti.
IV. Sectio: **Macroglossae** León Rev. Soc. Geogr. Cub. **4:** 5. 1931.
(Syn.: Series *Torreanae* León in Mem. Soc. Cub. Hist. Nat. **10:** 204. 1936.)
Palmae caudice ± tenui, usque ad 20 cm in diámetro, foliis cuneiformibus vel semiorbicularibus, viridibus, floribus solitariis,anello staminali lobulis 3 + 3 inaequalibus suffulto.

6.2. **Copernicia macroglossa** Wendl. ex Becc. Webbia **2:** 177. 1907.
(Syn.: *C. Torreana* León Rev. Soc. Geogr. Cub. **4:** 40. 1931.)

V. Sectio: **Rigidae** León Rev. Soc. Geogr. Cub. **4:** 35. 1931.
Foliis cuneiformibus, floribus fasciculatis, anello staminali lobulis 6 aequalibus suffulto.

6.3. **Copernicia rigida** Britt. et Wils. Bull. Torr. Bot. Cl. **41:** 17. 1914.
(Syn.: *C. rigida* f. *fissilingua* León Mem. Soc. Cub. Hist. Nat. **10:** 210. 1936.)

*Fig. 12.* Copernicia macroglossa Wendl. ex Becc. en un matorral serpentinoso seco («cuabal») al pié de la Loma Galindo, Matanzas. (Foto: A. BORHIDI)

6.4. **Copernicia longiglossa** León Mem. Soc. Cub. Hist. Nat. **10:** 210. 1936.

6.5. **Copernicia oxycalyx** Burret Kungl. Svensk. Vet. Akad. Handl. ser. 3. **6** (7): 6. 1929. (Syn.: *C. Clarkii* León Mem. Soc. Cub. Hist. Nat. **10:** 213. 1936.)

VI. Sectio: **Albae** Borhidi et Muñiz **sect. n.**

Foliis orbicularibus, ramulis floriferis 4–7 cm longis, floribus fasciculatis, filamentis longis, basi dilatatis, anello staminali lobis subcordiformibus magnis 6 aequalibus suffulto, ovario vertice hirsuto. Typus sectionis: *C. alba* Morong.

VII. Sectio: **Yareyes** León em. Muñiz

(Series *Yareyes* León Rev. Soc. Geogr. Cub. **4:** 36. 1931. p.p.)

Palmae robustae, caudice alto et crasso 30–80 cm in diametro, floribus solitariis vel fasciculatis, petiolo robusto, ápice 3.5–9 cm lato.

VII.a. Subsectio: **Yareyes**

Palmae robustae floribus fasciculatis.

6.6. **Copernicia Curbeloi** León Rev. Soc. Geogr. Cub. **4:** 53. 1931. (Syn.: *C. Molineti* var. *cuneata* León Mem. Soc. Cub. Hist. Nat. **10:** 216. 1936.; *C. Sueroana* var. *semiorbicularis* León l.c. 216. 1936.)

*Fig. 13.* Copernicia rigida Britt. et Wils. formando una sabana subcostera sobre serpentina de la Playa de Vaca, Moa. (Foto: A. BORHIDI)

6.7. **Copernicia Baileyana** León Rev. Soc. Geogr. Cub. **4:** 52. 1931.
(Syn.: *C. Baileyana* var. *laciniosa* León Mem. Soc. Cub. Hist. Nat. **10:** 224. 1936.; *C. Baileyana* f. *bifida* León l.c. 225. 1936.)

VII.b. Subsectio: **Fallaenses** Muñiz et Borhidi **subsect. n.**
Palmae robustae, caudice alto et crasso, floribus solitariis.

6.8. **Copernicia fallaensis** León (correctio nominis) Rev. Soc. Geogr. Cub. **4:** 51. 1931.
(Syn.: *C. fallaense* León l.c.; error grammaticalis obvius.)

VIII. Sectio: **Brittonianae** León em. Muñiz
(Series *Brittonianae* León Rev. Soc. Geogr. Cub. **4:** 36. 1931 + Series *Yareyes* León l.c. p. maj. p.)
Palmae medianae vel parvae caudice usque ad 25 cm in diametro, petiolo apice 1–3.5 cm lato, ramulis floriferis plerumque 2–8 cm longis, floribus in fasciculis 2–4-floris.
VIII.a. Subsectio: **Brittonianae**
Ramuli fructiferi non irregulariter incrassati, anello staminali lobulis 3 + 3 inaequalibus suffulto.

6.9. **Copernicia Cowellii** Britt. et Wils. Bull. Torr. Bot. Cl. **41:** 17. 1914.

*Fig. 14.* Copernicia Baileyana León en las sabanas arenosas de «Las Arenas» al Sur de Victoria de las Tunas. (Foto: A. BORHIDI)

6.10. **Copernicia humicola** León Mem. Soc. Cub. Hist. Nat. **10:** 221. 1936.

6.11. **Copernicia Molineti** León Rev. Soc. Geogr. Cub. **4:** 55. 1931.

6.12. **Copernicia Brittonorum** León Rev. Soc. Geogr. Cub. **4:** 49. 1931.
(Syn.: *C. Brittonorum* var. *acuta* León Mem. Soc. Cub. Hist. Nat. **10:** 222. 1936.; *C. Brittonorum* var. *sabaloense* León l.c. 223. 1936.)

VIII.b. Subsectio: **Roigianae** Muñiz et Borhidi **subsect. n.**
Ramulis fructiferis irregulariter incrassatis, anello staminali lobulis 6 aequalibus suffulto.

6.13. **Copernicia Yarey** Burret Kungl. Svensk. Vet.-Acad. Handl. ser. 3. **6** (7): 7. 1929.
(Syn.: *C. holguinensis* León Rev. Soc. Geogr. Cub. **4:** 48. 1931.)

6.13.1. **var. Yarey**

6.13.2. **var. robusta** León Mem. Soc. Cub. Hist. Nat. **10:** 221. 1936.

6.14. **Copernicia Roigii** León Rev. Soc. Geogr. Cub. **4:** 47. 1931.

*Fig. 15.* Copernicia Cowellii Britt. et Wils. en las sabanas serpentinosas al Sur de Minas, Prov. Camagüey. (Foto: A. BORHIDI)

IX. Sectio: **Hospitae** León em. Muñiz
(Series *Hospitae* León Rev. Soc. Geogr. Cub. **4:** 36. 1931. p.p.; Series *Pauciflorae* León l.c.; Series *Hospitae* León Mem. Soc. Cub. Hist. Nat. **10:** 204. 1936. p. min. p.)
Palmae medianae vel parvae foliis orbicularibus, ramulis floriferis 0.5–2 cm longis, floribus solitariis, anello staminali lobulis 6 subaequalibus suffultae.

6.15. **Copernicia glabrescens** Wendl. ex Becc. Webbia **2:** 170. 1907.
[Syn.: *C. ramosissima* Burret Kungl. Svensk. Vet.-Acad. Handl. ser. 3. **6** (7): 8. 1929.; *C. glabrescens* var. *havanensis* León Mem. Soc. Cub. Hist. Nat. **10:** 217. 1936.]
6.15.1. **var. glabrescens**
6.15.2. **var. ramosissima** (Burret) Muñiz et Borhidi **comb. n.** et **status n.**.
(Basionymon: *Copernicia ramosissima* Burret Kungl. Svensk. Vet.-Akad. Hand. ser. 3. **6** (7): 8. 1929.)
6.16. **Copernicia hospita** Martius Hist. Nat. Palm. **3:** 242. 1838.
(Syn.: *C.*×*Escarzana* León Rev. Soc. Geogr. Cub. **4:** 42. 1931.)
6.17. **Copernicia Curtissii** Becc. Webbia **2:** 176. 1907.
(Syn.: *C. pauciflora* Burret l.c. 8. 1929.; *C. clarensis* León Rev. Soc. Geogr. Cub. **4:** 45. 1931.; *C. hospita* var. *clarensis* León Mem. Soc. Cub. Hist. Nat. **10:** 219. 1936.)

*Fig. 16.* Copernicia glabrescens Wendl. ex Becc. var. ramosissima (Burret) Muñiz et Borhidi en bosque semideciduo subcostero de la Bajada, Peninsula de Guanahacabibes. (Foto: A. Borhidi)

**Espécies hibridógenas** fuera de secciones:

6.18. **Copernicia × Burretiana** (León) Muñiz et Borhidi **stat. n.**
(*Copernicia hospita × macroglossa*)
(Basionymon: *C. Burretiana* León Mem. Soc. Cub. Hist. Nat. **10:** 208. 1936. — Syn.: *C. macroglossa* Wendl. ex Becc. Webbia **2:** 177. 1907. p.p.; *C. macroglossa* León in Rev. Soc. Geogr. Cub. **4:** 44. 1931.; *C. Leoniana* Dahlgr. et Glassman Principes **2:** 103. 1958.)

6.19. **Copernicia × vespertilionum** León Rev. Soc. Geogr. Cub. **4:** 57. 1931.
(*Copernicia gigas × rigida*)
[Syn.: *C. vespertilionum* (León) León Mem. Soc. Cub. Hist. Nat. **10:** 212. 1936.]

6.20. **Copernicia × Sueroana** León Rev. Soc. Geogr. Cub. **4:** 44. 1931.
(*Copernicia hospita × rigida*)
[Syn.: *C. Sueroana* (León) León Mem. Soc. Cub. Hist. Nat. **10:** 215. 1936.]

6.21. **Copernicia × textilis** (León) Dahlgr. et Glassm. in Gent. Herb. **2:** 199. 1963.
(*Copernicia hospita × Baileyana*)
(Syn.: *C. textilis* León Rev. Soc. Geogr. Cub. **4:** 54. 1931.)

6.22. **Copernicia × Shaferi** Dahlgr. et Glassm. Principes **3:** 87. 1959.
(*Copernicia hospita × Cowellii*)

6.23. **Copernicia × occidentalis** (León) Muñiz et Borhidi **stat. n.**
(*Copernicia Curtissii × Brittonorum*)
(Basionymon: *C. occidentalis* León Mem. Soc. Cub. Hist. Nat. **10:** 218. 1936.)

*Fig. 17.* Sabal parviflora Becc. formando una sabana húmeda despues de la tala de un bosque aluvial original en la Ciénaga de Zapata. (Foto: A. Borhidi)

## I.C. Tribus: *Sabaleae*
## (Sabal alliance H. E. Moore 1973)

### 7. **SABAL** Adans. ex Guers. Bull. Sci Soc. Philom. **87:** 205. t. 25. 1804

1 a Segmentos centrales de las hojas no filiferos, 3-acostillados; flores de 5–6 m de largo con pétalos extendidos o retrorsos, madurando mayormente 2 carpelos . . . **1. S. Yapa**

b Segmentos de las hojas filiferos, todos 1-acostillados; flores de 3–5 mm de largo con pétalos erguidos, madurando un solo carpelo . . . . . . . . . . . . . . . . . . . . . **2. S. parviflora**

### Subgenus: **Inodes** Small Man. Southeast. Fl. 239. 1902.

7.1. **Sabal Yapa** Wright ex Becc. Webbia **2:** 64. 1907.
(Syn.: *Inodes Yapa* Standl. Contr. US. Nat. Hat. Herb. **23:** 71. 1920.; *S. mayarum*

*Fig. 18.* Prestoea montana (R. Graham) Nichols. en las pluvisilvas montanas de la Sierra de Gran Piedra sobre Santiago de Cuba. (Foto: A. BORHIDI)

H. H. Bartlett Carn. Inst. Publ. **35:** 461. 1935.; *S. peregrina* Bailey Gent. Herb. **6:** 400. 1944.; *S. yucatanica* Bailey l.c. 418. 1944.)

7.2. **Sabal parviflora** Becc. Webbia **2:** 43. 1907.
(Syn.: *S. florida* Becc. l.c. 46. 1907.; *S. mexicana* Sauv. Fl. Cub. 152. 1873.; *S. maritima* Burret.)

## II. Subfamilia: ARECOIDEAE

### II.A. Tribus: *Pseudophoeniceae*

(Pseudophoenicoid palms. H. E. Moore 1973.)

### 8. **PSEUDOPHOENIX** Wendl. Bot. Gaz. **11:** 314. 1886

8.1. **Pseudophoenix Sargenti** Wendl. l.c.
8.1.1. **ssp. Saonae** (O. F. Cook) H. W. Read Gent. Herb. **10:** 204. 1968.
(Syn.: *P. Saonae* O. F. Cook J. Wash. Acad. Sci. **13:** 406. 1923.)

### II.B. Tribus: *Chamaedoreae*

(Chamaedoreoid palms H. E. Moore 1973.)

## 9. **GAUSSIA** Wendl. Goett. Nachr. 1865*:* 327

9.1. **Gaussia princeps** Wendl. l.c. 328. 1865.

### II.C. Tribus: *Euterpeae*
### (Euterpe alliance H. E. Moore 1973.)

## 10. **PRESTOEA** Hook. f. in Benth. et Hook. Gen. Plant. **3:** 899. 1883

10.1. **Prestoea montana** (R. Grah.) Nichols.
(Syn.: *Euterpe globosa* Gaertn. Fruct. et Sem. **1:** 24. 1788.)

### II.D. Tribus*: Roystoneae*
### (Roystonea alliance H. E. Moore 1973.)

## 11. **ROYSTONEA** O. F. Cook, Science, ser. II. **12:** 479. 1900. Bull. Torr. Bot. Cl. **28:** 549. 1901

(Syn.: *Oreodoxa* Kunth in HBK. Nov. Gen. et Spec. **1:** 305. 1815. p.p.; Martius Hist. Nat. Palm. **3:** 166. 1838. non Willd.)

1 a Espata externa muy dilatada en la base; los tres estigmas 2-apendiculados en la base; fruto con micropilo rodeadó de una estrella en relieve ............... **4. R. stellata**
b Espatas externas no dilatadas en la base, estigmas no apendiculadas; exocarpio del fruto plano alrededor del micropilo (Sect. *Roystonea*) ........................ 2
2 a Corteza rojiza, flores masculinas moradas, pistilodio alargado, cónico*;* semillas oblongas, apiculadas en la base ........................................ **3. R. violacea**
b Corteza de color gris, flores masculinas blancuzcas ad amarillentas; pistilódio subgloboso; semillas elipticas, redondeadas en ambos estremos .................... 3
3 a Hojas mates al secar, el raquis sin procesos filiformes; sépalos masculinos de igual largo y ancho, espádices 2 o 3-ramificados .......................... **1. R. regia**
aa Espádice 2-ramificado, flor masculino de hasta 6 mm, fruto de 11–13 mm de largo ........................................................ 1a. **var. regia**
bb Espádice 3-ramificado, flor masculino de hasta 8 mm, fruto de 14–15 mm de largo ........................................................ 1b. **var. pinguis**
b Hojas lustrosas al secar, el raquis con procesos filiformes o lineares, a veces ramificados; sépalos masculinos reniformes, dos veces mas anchos que largos ..... **2. R. lenis**

### Sectio: **Roystonea**
### (Syn.: Sectio *Euroystonea* León Mem. Soc. Cub. Hist. Nat. **17:** 5–6. 1943.)

11.1. **Roystonea regia** (HBK.) O. F. Cook l.c.
(Syn.: *Oreodoxa regia* HBK. Nov. Gen. et Spec. **1:** 305. 1815.; *Roystonea floridana* Cook in Bull. Torr. Bot. Cl. **38:** 554. 1901.)
11.1.1. **var. regia**
11.1.2. **var. pinguis** Bailey Gent. Herb. **3:** 378. 1935.

*Fig. 19.* El palma real cubano. Roystonea regia (HBK) O. F. Cook — con un campesino colectando rácimos de frutos. (Foto: A. Borhidi)

11.2. **Roystonea lenis** León Mem. Soc. Cub. Hist. Nat. **17:** 8. 1943.

11.3. **Roystonea violacea** León l.c. 10. 1943.

### Sectio: **Astrophora** León l.c. 5. 1943.

11.4. **Roystonea stellata** León l.c. 11. 1943.

## III. Subfamilia: COCOSOIDEAE
## III.A. Tribus: *Cocoineae*

### 12. **COCOS** L. Gen. Plant. 1735

12.1. **Cocos nucifera** L. Spec. Plant. 1753: 1188.

*Fig. 20.* Una población naturalizada del coco — Cocos nucifera L. — en el matorral costero de la Punta Maisi. (Foto: A. BORHIDI)

II.A.b. Subtribus: Attaleae
(Attalea unit H. E. Moore 1973.)

13. **SCHEELEA** Karst. in Linnaea **28:** 264. 1856

13.1. **Scheelea cubensis** Burret Notizbl. Bot. Gart. Berlin **10:** 671. 1929.

III.B. Tribus: *Elaeineae*
(Elaeis alliance H. E. Moore 1973.)

14. **ELAEIS** Jacq. Stirp. Select. Amer. 1763: 280. t. 172

14.1. **Elaeis guineensis** Jacq. l.c.

*Fig. 21.* Acrocomia pilosa León en la localidad clásica entre Guantánamo y Jamaica. (Foto: A. Borhidi)

## III.C. Tribus: *Bactrineae*
## (Bactris alliance H. E. Moore 1973.)

### 15. **ACROCOMIA** Martius Hist. Nat. Pal. **3:** 285. 1838

1 a Tronco inerme o poco espinoso, pinnas glaucas en el envés, sépalos masculinos fimbriado-pelosos en el ápice .......... **1. A. subinermis**

b Tronco muy espinoso, pinnas verdes y pelosas en el envés; sépalos masculinos enteros y glabros .......... 2

2 a Raquis de las hojas setuloso-peloso; sétalos femeninos 3-lobulados en el ápice, con lóbulos apiculados fimbriados, ovario suavemente fibroso-pubescente, fruto de 4–4.5 mm de diámetro .......... **2. A. aculeata**

b Raquis de las hojas no setuloso-pubescente; pétalos femeninos truncados y emarginados en el ápice; ovario glabro, algo furfuraces en la base, fruto de 3.5 cm de diámetro .......... **3. A. pilosa**

15.1. **Acrocomia subinermis** León ex Bailey Hort. Second. 22. 1941.
15.2. **Acrocomia aculeata** (Jacq.) Lodd. ex Mart. Hist. Nat. Palm. **3:** 285. 1838.
(Syn.: *Cocos aculeatus* Jacq. Stirp. Select. Amer. 1763: 278. t. 169.)
15.3. **Acrocomia pilosa** León Mem. Soc. Cub. Hist. Nat. **14:** 52. 1940.

## 16. GASTROCOCOS Morales Rep. Fis. Nat. Isla de Cuba 1: 57. 1865

16.1. **Gastrococos crispa** (HBK.) H. E. Moore Principes **11:** 121. 1967.
[Syn.: *Cocos crispa* HBK. Nov. Gen. et Spec. **1:** 302. 1815.; *Acrocomia crispa* (HBK.) C. F. Baker ex Becc. Pomona Coll. J. Econ. Bot. **2:** 364. 1912.; *Gastrococos armentalis* Morales l.c. 58. 1865.; *Acrocomia armentalis* (Morales) Bailey in Hort. Second. 22. 1941.]

*Fig. 22.* Gastrococos crispa (HBK) H. E. Moore en las sabanas serpentinosas de Camajuani, NE de Santa Clara. (Foto: A. Borhidi)

## 17. BACTRIS Jacq. Stirp. Select. Amer. 1763: 217. t. 256

17.1. **Bactris cubensis** Burret Kungl. Svensk. Vet.-Acad. Handl. Ser. 3. **6** (7): 25. 1929.
(Syn.: *B. Plumieriana* Becc. Pomona Coll. J. Econ. Bot. **2:** 371. 1912. non Mart.)

## IV. Subfamilia: GEONOMOIDEAE
## IV.A. Tribus: *Pholidostachyeae*
## (Pholidostachys alliance H. E. Moore 1973 )

*Fig. 23.* Bactris cubensis Burret en las pluvisilvas montanas esclerófilas serpentinosas del Alto de la Iberia. (Foto: A. Borhidi)

18. **CALYPTRONOMA** Griseb. Fl. Brit. W. I. 1864: 518 (*Geonoma* auct. non Willd.; Cocops O. F. Cook Bull. Torr. Bot. Cl. **28:** 568. 1901. *Calyptrogyne* sensu Maza Dicc. Bot. 1889: 72, sensu León Contr. Ocas. Mus. Hirt. Nat. Col. de la Salle No. **3:** 10. 1944, Fl. de Cuba **1:** 243. 1946. non Wendl. Bot. Zschr. 1859: 72.)

1 a Mesocarpio fibroso, acuminado en la base; semillas oblongo ovales de 4.5–6 mm de largo y 3–4.5 mm de ancho, asimétrica en la base, con una punta aguda sublateral; embrión subbasilar. Segmentos de las hojas enteros en el ápice, ferrugineas densamente punteadas con puntos no prominentes en el envés .......... **3. C. intermedia**

b Mesocarpio fibroso obtuso o redondeado en la base, semillas ovales a globosas sin punta aguda en la base. Segmentos de las hojas mayormente dividias en el ápice (enteros en *C. microcarpa*) .......................................... 2

2 a Segmentos de las hojas 5-nervias, enteras en el ápice, el envés ferrugineo; fruto de 7×8 mm, subgloboso; semillas subglobosas de 4–4.5 mm de diámetro, simétricas en la base, embrión basilar ........................................ **2. C. microcarpa**

b Segmentos de las hojas 7–9-nervias, divididas en el ápice, mayormente pálidos en el envés con puntos glanduliformes prominentes de tamaño variable. Frutos de 9–12 mm de largo y 7–10 mm de ancho ............................................ 3

3 a Semillas simétricas en la base, 6–7 mm de largo y 4.5–5 mm de ancho; embrión basilar; alvéolos mayormente triangulares, agudos en el ápice. Hojas con nervios secundarios y terciarios no prominulos, puntos glanduliformes de tamaño variable irregularmente dispersos en la superficie del envés ............................... **1. C. dulcis**

b Semillas asimétricas en la base, embrión subbasilar; alvéololos mayormente redondeados en el ápice ............................................ **4. C. Clementis**

ba Fruto globoso, mesocarpio fibroso libre de la semilla subglobosa de 6 mm de largo y 5.5–6 mm de ancho; hojas con nervios secundarios y terciarios no o poco prominulos, puntos glanduliformes irregularmente dispersos en el envés ................ ................................................ **4a. ssp. Clementis**

bb Fruto aovado a eliptivo, mesocarpio fuertemente adherente a la semilla aovada de 6 mm de largo y 4–5 mm de ancho; nervios secundarios y terciarios prominulos, puntos glanduliformes pequeños dispuestos en rayas más a menos regulares en los nervios del envés ........................................ **4b. ssp. orientensis**

18.1. **Calyptronoma dulcis** (Wr. ex Griseb.) Bailey Gentes Herb. **4:** 168. (1938). (Basionymon: *Geonoma dulcis* Wr. ex Griseb. Cat. Plant. Cub. 1866: 222. — Syn.: *Calyptrogyne dulcis* Maza Dicc. Bot. 1889: 72.; *Calyptrogyne swartzii* Becc. Pomona Coll. J. Econ. Bot. **2:** 356. 1912.)

18.2. **Calyptronoma microcarpa** (León) A. D. Hawkes Phytologia **3:** 145. (1949). (Basionymon: *Calyptrogyne microcarpa* León Contr. Ocas. Mus. Hist. Nat. Col. de la Salle No. **3:** 10. 1944.)

18.3. **Calyptronoma intermedia** (Griseb. et Wendl.) Wendl. in Kerch. Palm. 1878: 238. (Basionymon: *Geonoma intermedia* Griseb. et Wendl. in Sauvelle Fl. Cuba 1973: 153. — Syn.: *Calyptrogyne intermedia* Maza Noc. Bot. Sist. 1893: 50.)

18.4. **Calyptronoma Clementis** (León) A. D. Hawkes Phytologia **3:** 145. (1949). (Basionymon: *Calyptrogyne clementis* León Contr. Ocas. Mus. Hist. Nat. Col. de la Salle No. **3:** 11. 1944. — Syn.: *Geonoma swartzii* Griseb. et Wendl. ex Griseb. Cat. Plant Cub. 1866: 222. excl. syn.: *Calyptrogyne swartzii* Becc. Pomona Coll. J. Econ. Bot. **2:** 356. 1912. quoad Wright 1466.)

18.4.1. **ssp. clementis**

18.4.2. **ssp. orientensis** Muñiz et Borhidi **ssp. nova**

Palma 4–10 m alta; folia 3–4 m longa, segmenta 3.5–4 cm distantes, centralia 75–95 cm longa, 5–6 cm lata, supra nitida, subtus opaca, viridia, 7–9-nervia, longe acuminata, apice bifida, nervis secundariis utrinque prominulis, tertiariis supra obsoletis vel inconspicuis, subtus manifeste prominulis et punctis minutis pallidis glanduliformiter prominulis satis regulariter dispositis, inter nervos punctis majoribus laxe et irregulariter obsitis, margine recurva suffulta. Spatha externa ± 50 cm longa et cca 6 cm lata; rami inflorescentiae plerumque 2–4, ramuli floriferi 14–25 cm longi, alveolae semiorbiculares vel ovales, apice rotundato, 8–11 mm longe distantes. Flores masculini 6–7 mm longi, sepala 3–4 mm longa, nigrocarinata, corolla 5.5–7 mm longa, tubus staminalis 2 mm longus, stamina inaequilonga, 0–1 mm longa, antherae 2 mm longae. Fructus ellipticο-ovalis, 1 cm longus et 0.8 cm latus; mesocarpium fibrosum basi longe attenuatum, subobtusum, seminum adhaerens. Semina ovata, 5.5–6 mm longa et 4–4.5 mm lata, basi leviter obliqua, embryo excentrica.

*Fig. 24.* Calyptronoma Clementis ssp. orientensis Muñiz et Borhidi al borde del Rio Anacleto, Reserva de Jaguani, Cuchillas de Moa, sobre serpentina. (Foto: A. BORHIDI)

**Typus:** ACUÑA 13019 SV; Cuba Prov. Oriente, Monte Centeno, Moa. Leg.: J. ACUÑA 12. nov. 1945. in fructibus.

Specimina examinata: LEÓN 22690 Monte Grande de Centero, Moa; Leg.: LEÓN, CLEMENTE et ALAIN, aug. 1945 (SV); — Sierra de Nipe: Cayo La Plancha, LEÓN et ALAIN 17999; ? Cayo de las Mujeres, pié de la Loma Mensura, leg.: LEÓN, MARIE-VICTORIN et ALAIN 19811 (SV); Sierra del Cristal: Barranca del Rio Lebisa. Leg.: ALAIN, ACUÑA et LÓPEZ-FIGUEIRAS 5720 (SV).

Palma de 4–10 m de alto; hojas pinnadas de 3–4 m de largo, segmentos apartados en 3.5–4 cm, los centrales de 75–95 cm de largo y 5–6 cm de ancho, verdebrillantes en el haz, pálidos en el envés, 7–9-nervios, largamente acuminados y bifidos en el ápice. Nervice secundarios prominulos en embas caras, los terciarios obsoletos en el haz, prominulos en el envés y cubiertos con rayas de puntos minutos pálidos en forma ± regular, y con puntos mayores glanduliformes irregularmente esparcidos entre los nervios del envés; el margen algo recurvo. Espata exterior de ± 50 cm de largo y 6 cm de ancho unicarinada, interior de 120 cm de largo y 6 cm de ancho. Ramas de la inflorescencia 2–4, ramitas floriferas de 14–25 cm de largo, alvéolas semiorbiculares vel ovales, el ápice redondeado desde bráctea 8–11 mm apartadas. Flores masculinas de 6–7 mm de largo, sépalos de 3–4 mm, negro-carinados, corola de 5.5–7 mm de largo, tubo estaminal de 2 mm de largo, filamentos desiguales de 0–1 mm de largo, anteras de 2 mm. Fruto eliptico-aovado, de 1 cm de largo y 0.8 cm de ancho, el mesocarpio fibroso largamente estrechado en la base subobtusa, pegado a la semilla. Semillas aovadas de 6 mm de largo y 4–4.5 mm de ancho, ligeramente oblicuas en la base, el embrio subbasilar.

Esta sub espécie se distingue del *Calyptronoma Clementis* por sus hojas y frutos. LEÓN no teniendo material fructificado de las Montañas serpentinosas

del Norte de Oriente supusó, que la palma manaca de esta zona fuera idéntica con las de la Sierra Maestra. La ssp. *orientensis* al parecer es endémica de las montañas de serpentina del Masizo Sagua Baracoa (provincias Holguin y Guantánamo).

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# FLOWERING BIOLOGICAL AND GROWTH CHARACTERISTICS OF MALUS SPECIES AND CULTIVARS

J. Nyéki,[1] A. Terpó,[2] M. Tóth,[1] F. Gyuró[1] and M. Soltész[3]

[1] UNIVERSITY OF HORTICULTURE, DEPARTMENT OF FRUIT GROWING, BUDAPEST
[2] UNIVERSITY OF HORTICULTURE, BOTANY DEPARTMENT, BUDAPEST
[3] COLLEGE OF HORTICULTURE UNIVERSITY, KECSKEMÉT

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The elaboration of the *Malus* pollination scheme was begun in 1977. In 1977 the flowering biological observations were carried out on 17 individuals and in 1978 on 19 ones. On the basis of the main period flowering and the rate of flowering four groups were formed from *Malus* species. We determined the species (types) which were flowering together with the commercial apple varieties. Only more (at least two) *Malus* species give secure (above 50 per cent) overlapping with the commercial apple varieties. In intensive orchards *Malus* species (types) of medium growth strength and favourable foliage habit can be used.

## Introduction

One of the vital questions of intensive apple growing is ensuring optimal seed formation. The commercial apple varieties cultivated in Hungary are self-sterile, therefore, high production values can be achieved only by matching such variety pairs which have their flowering periods in correspondence and that possibly fertilize one another also.

Another condition for high production values and good quality of the cultivar is the agrotechnique specialized for the requirements of the cultivar. There are rather great differences with respect to the agrotechnical demands — among them first of all that of pruning, plant protection and harvesting — in the individual varieties. In planting several cultivars in association it is difficult to pay attention to the differences in requirements.

By recognizing the technological and economical advantages of single-variety orchards, British researchers began to examine the possibilities of applying *Malus* species as pollinators in 1965 (Williams 1975).

Following from favourable foreign experiences (McGregor 1976, Williams 1977), we began the elaboration of the *Malus* pollination scheme at the Fruit Growing and Botany Department of the University of Horticulture (Budapest) in 1977 (Gyuró et al. 1978).

The flowering biological and growth characteristics are essential determinants in using *Malus* species as pollinators. The observations were directed at the following questions:

(1) When does the flowering of the individual *Malus* species begin according to the calendar?
(2) How many days does the flowering last for the *Malus* species?
(3) How do flowering dynamics change on the basis of the number of flowers that shoot daily and cease to flowering daily?
(4) Into what in groups can *Malus* species be categorized and what kind of overlapping do they show in relation to the cultivars to be pollinated?
(5) What are the growth type and habitat of the *Malus* species like from the viewpoint of placing them into orchards?

**Table 1**

*The dynamics of flower shooting in Malus species (types)*

| Code number | April | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| SBK-9 | 10.1 | 17.7 | 29.1 | 36.0 | 39.8 | 44.9 | 13.9 | 13.9 | 10.1 | 8.8 | 4.4 |
| SBK-1 | 14.7 | 18.3 | 24.8 | 26.2 | 36.3 | 46.4 | 32.7 | 33.4 | 13.3 | 12.2 | 10.0 |
| SBK-730 | 7.9 | 20.8 | 32.7 | 41.6 | 51.5 | 64.3 | 48.5 | 35.6 | 14.8 | 13.9 | 6.9 |
| SBK-10 | 3.5 | 7.8 | 14.9 | 21.0 | 25.4 | 30.7 | 41.2 | 44.7 | 32.4 | 28.9 | 25.4 |
| BK-731 | 2.1 | 4.3 | 7.9 | 12.2 | 17.2 | 23.7 | 38.1 | 44.6 | 37.4 | 30.2 | 29.5 |
| SBK-5 | 2.8 | 5.2 | 11.5 | 13.2 | 14.4 | 16.7 | 22.5 | 22.5 | 24.2 | 21.9 | 20.2 |
| SBK-726 | | 4.6 | 10.0 | 15.3 | 20.0 | 24.6 | 37.6 | 46.9 | 26.1 | 19.2 | 12.3 |
| SBK-280 | | 3.6 | 7.9 | 12.2 | 17.2 | 23.7 | 38.1 | 44.6 | 37.4 | 30.2 | 29.4 |
| SBK-7 | | 2.9 | 7.3 | 11.0 | 12.5 | 15.4 | 25.0 | 38.2 | 40.4 | 41.9 | 42.6 |
| SBK-336 | | | 2.3 | 7.7 | 10.0 | 14.7 | 24.0 | 23.2 | 16.2 | 20.9 | 13.1 |
| SBK-333 | | | 1.4 | 4.2 | 10.0 | 15.0 | 32.8 | 37.1 | 29.2 | 12.1 | 7.8 |
| SBK-6 | | | 1.9 | 10.6 | 11.8 | 12.6 | 24.1 | 33.9 | 27.2 | 16.9 | 15.4 |
| SBK-2 | | | 5.2 | 5.2 | 5.2 | 7.0 | 15.7 | 19.2 | 21.0 | 26.3 | 42.1 |
| SBK-277 | | | | 2.7 | 6.4 | 11.9 | 11.9 | 20.1 | 37.6 | 19.2 | 17.4 |
| SBK-3 | | | | 0.4 | 0.4 | 0.8 | 6.0 | 10.1 | 12.9 | 14.8 | 26.3 |
| SBK-1014 | | | | | | | 0.9 | 4.9 | 5.8 | 7.8 | 20.5 |
| SBK-1003 | | | | | | | | 7.3 | 10.9 | 13.4 | 43.9 |
| Starking | | | | | | 2.6 | 4.4 | 5.7 | 16.8 | 22.2 | 35.1 |
| Jonathan | | | | | | | 1.0 | 2.9 | 4.3 | 4.8 | 9.7 |

## Material and method

Our observations were made in the Soroksár (southern edge of Budapest) Botany Garden (= SBK) of the Botany Department of the University of the Horticulture. The garden lies in a flat area, its altitude is of 115 m above sea level. The soil is sandy, in places with more bounded spots. The annual mean temperature is +10.2 °C, the monthly mean value in April is +10.6 °C, in May +16.1 °C. The annual precipitation is on the average 552 mm, the average in April is 45 mm, in May 63 mm (Terpó and Bogya 1978).

The most important characteristics prevailing in the periods of observation (daily mean temperature, precipitation) are presented in Figs 1 and 2, together with the flowering phenological data. The measurement was carried out in the neighbouring Pestlőrinc Centre of the Central Institute for Atmospheric-Physical Research. In 1977, the weather was dry and warm, while in 1978 it was cool and rainy.

In 1977, the observations were carried out on 17 individuals and in 1978 on 19 ones, which were on their own root. Occasionally, several types were chosen within one and the other cultivars. The botanical designation of the types used in the observation with their number of identification is as follows:

SBK-1: *Malus floribunda* var. atropurpurea
SBK-2: *M.* × *purpurea* var. helleriana
SBK-3: *M. floribunda*

*(percentage of shot, functionable flowers, Soroksár 1977)*

| April | | | | | | | | May | | | | | Duration of flowering (day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 1 | 2 | 3 | 4 | 5 | |
| 1.2 | 0.6 | | | | | | | | | | | | 13 |
| 2.8 | 0.3 | | | | | | | | | | | | 13 |
| 6.9 | 2.9 | | | | | | | | | | | | 13 |
| 24.5 | 8.7 | 2.6 | 0.8 | | | | | | | | | | 15 |
| 9.3 | 2.1 | | | | | | | | | | | | 13 |
| 26.5 | 31.2 | 42.7 | 12.0 | 2.3 | 0.5 | | | | | | | | 17 |
| 6.9 | 1.5 | | | | | | | | | | | | 12 |
| 9.3 | 2.1 | | | | | | | | | | | | 12 |
| 31.6 | 8.8 | 7.3 | 0.7 | | | | | | | | | | 14 |
| 14.7 | 9.3 | 3.8 | 1.5 | 1.5 | | | | | | | | | 14 |
| 4.2 | | | | | | | | | | | | | 10 |
| 10.6 | 7.1 | 6.7 | 2.3 | 1.2 | 0.7 | | | | | | | | 15 |
| 68.4 | 50.8 | 50.8 | 17.5 | 12.2 | 1.7 | | | | | | | | 15 |
| 10.0 | 2.7 | 1.8 | | | | | | | | | | | 11 |
| 34.2 | 27.7 | 18.9 | 16.6 | 16.2 | 11.1 | 9.2 | 4.1 | | | | | | 16 |
| 32.3 | 30.3 | 25.4 | 17.6 | 9.8 | 9.8 | 9.8 | 3.9 | 1.9 | | | | | 14 |
| 52.4 | 19.5 | 15.8 | 3.6 | 2.4 | | | | | | | | | 9 |
| 44.0 | 37.3 | 23.5 | 17.3 | 13.3 | 8.4 | 6.6 | 5.3 | 4.8 | 1.3 | | | | 16 |
| 11.5 | 12.9 | 11.5 | 5.1 | 6.7 | 8.3 | 10.2 | 16.7 | 21.2 | 22.3 | 13.4 | 5.3 | 1.3 | 18 |

SBK-4: *Sorbomalus*
SBK-5: *M. baccata*
SBK-6: *M. spectabilis*
SBK-7: *M. baccata*
SBK-8: *M. baccata*
SBK-9: *M. floribunda* var. atropurpurea
SBK-10: *M. halliana*
SBK-277: *M. dasyphylla*
SBK-280: *M. silvestris*
SBK-333: *M. silvestris*
SBK-336: *M. pumila*
SBK-726: *M. silvestris*
SBK-730: *M. silvestris*
SBK-731: *M. silvestris*
SBK-1003: *M. domestica-pumila*
SBK-1014: *M. dasyphylla-pumila*

Jonathan and Starking trees on M4 rootstock were chosen as the control in 1977. Two intergrafted Jonathan and Starking trees each were chosen as controls in 1978. Jonathan-I: M4/M4, Jonathan-II: Jonathan/M4; Starking-A on M4/M16, while Starking-B on Starking/M4 intergrafted rootstocks. The trees reached their period of full productiveness in 1978.

**Table 2**

*The dynamics of deflorescence of Malus species (types) (percentage of flowers*

| Code number | April | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| SBK-9 | 3.7 | 8.2 | 16.4 | 29.7 | 30.3 | 31.0 | 70.8 | 73.4 | 87.8 | 89.8 | 95.5 | 98.7 | 99.3 |
| SBK-1 | 3.2 | 6.8 | 11.1 | 14.7 | 15.4 | 17.6 | 35.2 | 58.2 | 81.2 | 85.2 | 86.3 | 97.1 | 99.6 |
| SBK-730 | | | 6.9 | 10.9 | 12.9 | 16.8 | 37.6 | 51.5 | 81.2 | 86.1 | 93.1 | 97.0 | 98.2 |
| SBK-10 | | | | 2.6 | 4.3 | 8.7 | 14.0 | 21.0 | 24.5 | 39.4 | 54.3 | 68.4 | 91.2 |
| SBK-731 | | | 0.7 | 1.4 | 1.4 | 2.1 | 12.9 | 15.1 | 44.6 | 61.8 | 67.6 | 89.9 | 97.1 |
| SBK-5 | | | | | | | | 0.5 | 0.5 | 0.5 | 1.7 | 17.3 | 34.6 |
| SBK-726 | | | | | | 0.7 | 16.9 | 27.6 | 73.8 | 77.6 | 86.1 | 93.0 | 98.5 |
| SBK-280 | | | 0.7 | 1.4 | 1.4 | 2.1 | 12.9 | 15.1 | 44.6 | 61.8 | 67.6 | 89.9 | 97.1 |
| SBK-7 | | | | | | 0.7 | 7.3 | 8.8 | 17.6 | 24.2 | 45.5 | 67.6 | 91.1 |
| SBK-336 | | | | | | 1.5 | 20.9 | 26.3 | 43.4 | 51.9 | 64.3 | 75.1 | 87.5 |
| SBK-333 | | | | 2.1 | 2.8 | 7.8 | 8.5 | 22.1 | 37.8 | 86.4 | 90.7 | 95.7 | 100.0 |
| SBK-6 | | | | | | | 3.9 | 15.4 | 32.8 | 54.9 | 65.2 | 80.2 | 90.1 |
| SBK-2 | | | | | | | | 1.7 | 3.5 | 3.5 | 5.2 | 17.5 | 36.8 |
| SBK-277 | | | | | | | 9.1 | 11.0 | 17.4 | 78.8 | 81.6 | 89.9 | 96.3 |
| SBK-3 | | | | | | | | | 3.7 | 4.1 | 5.5 | 7.8 | 35.1 |
| SBK-1014 | | | | | | | | 0.5 | 1.9 | 4.9 | 5.8 | 19.6 | 43.0 |
| SBK-1003 | | | | | | | | | | 4.8 | 9.7 | 37.8 | 53.6 |
| Starking | | | | | | | | | | 4.0 | 8.8 | 26.6 | 45.3 |
| Jonathan | | | | | | | | | | 2.1 | 4.3 | 9.4 | 19.1 |

For the flowering biological observations, on the average 150–250 pieces of flower buds were marked on parts of identical flower density, along the whole width of the foliage. Two stages of flowering were assessed daily, viz. the shooting and the ceasing of flowering, in the same phase of the day. Shooting was the stage in which the petals stretched at least to the extent that in the flower the circle of stamen and pistil became visible. The most important sign of deflorescence was the pistil becoming brown. From the data of the flowering dynamic, phenogrammes were drawn up and the groups of flowering periods in the individual species (types) were determined, together with the rate of correspondence in respect of flowering periods with the main apple varieties.

## Results and their assessment

### *Flowering period and duration of flowering*

The flowering period and the duration of florescence in *Malus* species (types) can be studied in Figs 1 and 2. In 1977, the flowering of the species drawn into the analysis was between April 12 and May 2; in 1978, between April 21 and May 8 — and in one type between May 16 and May 25. The control varieties had their flowering period in 1977 between April 17 and May 5; in 1978, between April 27 and May 11. In 1978, of the *Malus* species, SBK-2,

*that have ceased to flower and are unable to function, Soroksár 1977)*

| April | | | | | | May | | | | | | Duration of flowering (day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 26 | 27 | 28 | 29 | 30 | 1 | 2 | 3 | 4 | 5 | 6 | |
| 100 | | | | | | | | | | | | 14 |
| 100 | | | | | | | | | | | | 14 |
| 100 | | | | | | | | | | | | 12 |
| 97.3 | 99.1 | 100 | | | | | | | | | | 13 |
| 100 | | | | | | | | | | | | 12 |
| 48.5 | 88.0 | 93.7 | 99.4 | 100 | | | | | | | | 11 |
| 100 | | | | | | | | | | | | 9 |
| 100 | | | | | | | | | | | | 12 |
| 92.6 | 99.2 | 100 | | | | | | | | | | 11 |
| 92.2 | 98.4 | 100 | | | | | | | | | | 11 |
| | | | | | | | | | | | | 10 |
| 92.4 | 97.6 | 98.8 | 99.2 | 100 | | | | | | | | 12 |
| 43.8 | 82.4 | 87.7 | 98.2 | 100 | | | | | | | | 11 |
| 100 | | | | | | | | | | | | 8 |
| 37.0 | 60.1 | 72.2 | 83.7 | 90.7 | 95.8 | 100 | | | | | | 12 |
| 48.0 | 66.6 | 77.4 | 81.3 | 90.2 | 96.1 | 98.0 | 100 | | | | | 14 |
| 80.5 | 93.9 | 97.6 | 100 | | | | | | | | | 8 |
| 63.1 | 68.8 | 81.7 | 88.8 | 90.6 | 92.8 | 95.1 | 98.6 | 100 | | | | 13 |
| 24.5 | 25.8 | 33.4 | 37.1 | 40.9 | 47.7 | 52.0 | 71.9 | 83.8 | 94.6 | 98.6 | 100 | 16 |

SBK-270, SBK-280, SBK-333, SBK-726 and SBK-730 species (types) formed hardly any flowers, therefore, no observations could be carried out on them.

The main period of flowering was considered that stage when the highest percentage of the flowers was open and capable of functioning.

The flowering dynamics data are given in Tables 1–4. In 1977, the period of flowering in the case of *Malus* species (types) changed between 9–17 days, while the period of deflorescence between 8–17 days. In 1978, these periods were shorter (between 8–14 and 7–12 days), thus the flowering took a quicker course. The same was valid in relation to the control varieties as well. In the main flowering period, 20–70% of the flowers were in a functioning state varying according to species (types). In the control varieties, in the case of flowers growing on several year old canes, the average was 40–50%.

The rate of flowering in the *Malus* species (types) was mostly almost symmetrical, and it can be characterized by a curve having one peak of flowering. Exceptions are in 1977 SBK-5 and SBK-7, while in 1978 SBK-6 types, in which the main period of flowering became postponed to the end of the flowering period, and thus it became asymmetrical. In 1977, the florescence of Jonathan variety can be characterized by curves having two-fold flowering peaks. Such elapse in flowering can be experienced in the case of varieties which form flowers in abundance even on one-year old canes: as is known, on younger canes flowering ensues only later. One of the most important requirements in matching pollinator *Malus* species

**Table 3**

*The dynamics of flower shooting in Malus species (types)*

| Code number | April | | | | | | | | | | May | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 1 | 2 | 3 | 4 | 5 |
| SBK-9 | 1.0 | 3.8 | 14.5 | 39.2 | 30.1 | 31.7 | 33.3 | 8.1 | 5.9 | 3.8 | | | | | |
| SBK-10 | | 0.8 | 20.2 | 43.4 | 41.0 | 48.1 | 55.4 | 5.9 | 5.6 | 2.9 | | | | | |
| SBK-731 | | | 8.7 | 43.8 | 51.6 | 53.4 | 29.2 | 15.5 | 5.9 | 3.2 | | | | | |
| SBK-1 | | | 0.5 | 37.1 | 29.6 | 41.9 | 50.0 | 27.4 | 15.0 | 10.2 | 22.6 | 1.1 | | | |
| SBK-3 | | | | 6.4 | 13.8 | 18.0 | 22.8 | 45.0 | 64.6 | 76.7 | 13.8 | 5.8 | 4.8 | 2.1 | 2.1 |
| SBK-7 | | | | 4.5 | 7.2 | 21.5 | 25.1 | 16.1 | 25.6 | 33.6 | 14.8 | 8.1 | 4.9 | | |
| SBK-6 | | | | 3.5 | 9.9 | 17.3 | 33.7 | 46.5 | 53.5 | 43.1 | 1.5 | 0.5 | | | |
| SBK-5 | | | | 1.0 | 3.0 | 6.5 | 10.0 | 8.0 | 14.1 | 15.1 | 17.1 | 27.1 | 21.6 | 7.5 | 3.0 |
| SBK-336 | | | | | 12.5 | 24.0 | 27.9 | 41.4 | 30.8 | 24.0 | 5.8 | 2.9 | | | |
| SBK-1003 | | | | | | | | | 9.6 | 19.4 | 18.5 | 21.3 | 16.7 | 11.1 | 8.3 |
| SBK-8 | | | | | | | | | | | 2.9 | 4.4 | 7.7 | 19.3 | 58.5 |
| SBK-4 | | | | | | | | | | | | | | | |
| Jonathan-I | | | | | | | 2.0 | 6.1 | 12.3 | 15.4 | 27.7 | 34.6 | 40.0 | 27.8 | 21.5 |
| Jonathan-II | | | | | | | 5.0 | 10.0 | 15.0 | 28.2 | 36.2 | 22.8 | 21.5 | 14.1 | 6.0 |
| Starking-A | | | | | | | | | | | | 2.5 | 3.7 | 16.1 | 26.5 |
| Starking-B | | | | | | | | | | 2.0 | 4.0 | 16.0 | 24.0 | 34.0 | 53.0 |
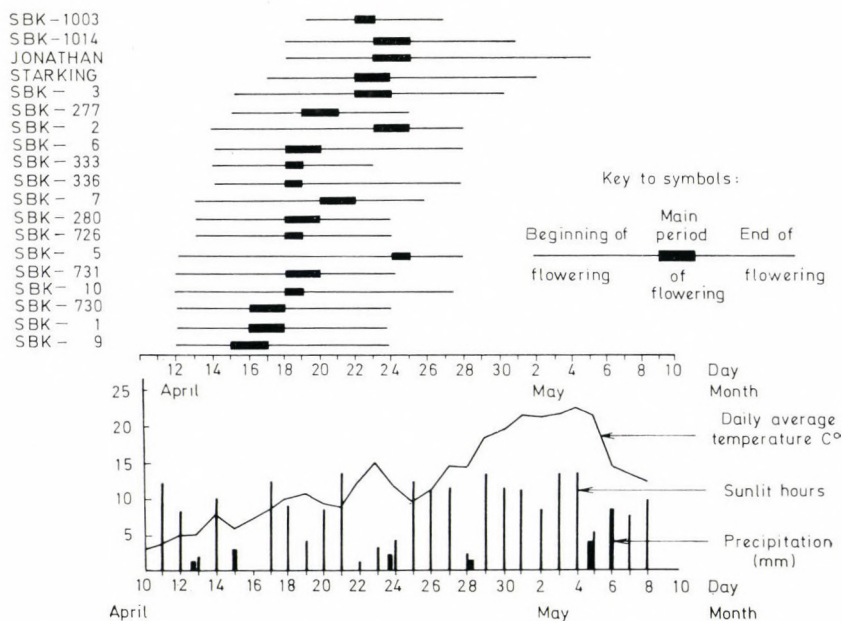
*Fig. 1.* **Period of flowering in *Malus* species (types) (Soroksár 1977)**

*(percentage of shot, functionable flowers, Soroksár 1978)*

| May | | | | | | | | | | | | | | | | Duration of flowering (day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 7 | 8 | 9 | 10 | 11 . . . 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | | |
| | | | | | | | | | | | | | | | | 10 |
| | | | | | | | | | | | | | | | | 9 |
| | | | | | | | | | | | | | | | | 8 |
| | | | | | | | | | | | | | | | | 10 |
| 2.6 | 1.1 | | | | | | | | | | | | | | | 14 |
| | | | | | | | | | | | | | | | | 10 |
| | | | | | | | | | | | | | | | | 9 |
| 2.0 | | | | | | | | | | | | | | | | 13 |
| | | | | | | | | | | | | | | | | 8 |
| 2.8 | | | | | | | | | | | | | | | | 8 |
| 20.8 | 13.5 | 2.4 | | | | | | | | | | | | | | 8 |
| | | | | | 3.8 | 6.7 | 16.5 | 25.4 | 32.6 | 20.3 | 24.2 | 12.3 | 12.3 | 7.6 | | 10 |
| 13.8 | 9.2 | 6.1 | 3.1 | | | | | | | | | | | | | 13 |
| 4.0 | 2.0 | 2.7 | | | | | | | | | | | | | | 12 |
| 37.6 | 20.4 | 14.8 | 3.7 | 3.7 | 1.2 | | | | | | | | | | | 10 |
| 31.0 | 18.0 | 12.0 | 2.0 | | | | | | | | | | | | | 10 |

***Fig. 2.*** **Period of florescence in *Malus* species (types) (Soroksár 1978)**

**Table 4**

*The dynamics of deflorescence of Malus species (types) (percentage of flowers*

| Code number | April | | | | | | | | May | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 1 | 2 | 3 | 4 | 5 | 6 |
| SBK-9 | | 10.7 | 27.9 | 41.9 | 47.8 | 90.3 | 94.0 | 96.2 | 100 | | | | | |
| SBK-10 | | 3.2 | 31.8 | 33.7 | 35.4 | 93.5 | 93.5 | 96.4 | 100 | | | | | |
| SBK-731 | | 1.3 | 16.8 | 27.4 | 53.8 | 78.0 | 94.0 | 96.8 | 100 | | | | | |
| SBK-1 | | | 23.6 | 36.0 | 39.7 | 67.2 | 82.7 | 88.7 | 97.8 | 98.9 | 100 | | | |
| SBK-3 | | | | | 2.1 | 6.8 | 7.9 | 8.4 | 81.4 | 89.4 | 91.3 | 95.2 | 96.8 | 96.8 |
| SBK-7 | | | 1.3 | 1.3 | 2.2 | 43.5 | 45.2 | 48.4 | 73.9 | 89.6 | 94.1 | 100 | | |
| SBK-6 | | | | | 0.1 | 13.3 | 35.6 | 52.9 | 72.2 | 99.5 | 100 | | | |
| SBK-5 | | | | | | | | 17.6 | 23.1 | 32.8 | 56.4 | 92.4 | 97.0 | 98.0 |
| SBK-336 | | | | | 1.0 | 18.2 | 38.4 | 58.6 | 82.6 | 96.1 | 100 | | | |
| SBK-1003 | | | | | | | | | 7.4 | 28.7 | 32.8 | 73.3 | 80.7 | 94.8 |
| SBK-8 | | | | | | | | | | 2.9 | 0.9 | 4.3 | 19.8 | 63.7 |
| SBK-4 | | | | | | | | | | | | | | |
| Jonathan-I | | | | | | | | 0.7 | 4.6 | 33.8 | 41.5 | 61.5 | 67.6 | 76.1 |
| Jonathan-II | | | | | | | | 1.3 | 12.7 | 63.7 | 68.4 | 79.8 | 87.2 | 92.6 |
| Starking-A | | | | | | | | | | | | 3.0 | 14.8 | 29.6 |
| Starking-B | | | | | | | | | | 2.0 | 4.0 | 7.0 | 20.0 | 49.0 |

with apple varieties is — besides the simultaneity in the main periods of flowering — the identical, or similar rate of flower opening, that is, phenogram of flower opening. By using several *Malus* species (types) together, a full overlapping with the flowering of the main variety can be achieved.

Groups of flowering periods:

For the determination of the flowering periods of apple varieties, four groups of flowering periods are taken into consideration (very early, mid-early, mid-late and very late). On the basis of the duration of flowering, the main period flowering, and the flowering phenogramme, *Malus* species can be grouped as shown in Table 5. Only the stable species (types) in the flowering period are indicated in the Table. Considering the relative flowering period, no essential deviation occurred in the two years.

Of the species (types) having a labile period of flowering, SBK-3 belonged in 1977 to the mid-late category, in 1978 to the mid-early one; SBK-10 and SBK-731 belonged in 1977 to the mid-early, while in 1978 to the very early group. Jonathan and Starking had their flowering period in both years in the mid-late group, therefore, the closest correspondence in flowering occurred with the *Malus* species (types) belonging in the mid-late group, or there was an overlapping of flowering with them. The latter produce a satisfactory overlapping primarily in years of quick flowering only, therefore they can be used as pollinators only if

*that have already ceased to flower and are unable to function, Soroksár 1978)*

| May | | | | | | | | | | | | | Duration of flowering (day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 8 | 9 | 10 ... 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | |
| | | | | | | | | | | | | | 8 |
| | | | | | | | | | | | | | 8 |
| | | | | | | | | | | | | | 8 |
| | | | | | | | | | | | | | 9 |
| 98.9 | 100 | | | | | | | | | | | | 12 |
| | | | | | | | | | | | | | 10 |
| | | | | | | | | | | | | | 7 |
| 100 | | | | | | | | | | | | | 7 |
| 100 | | | | | | | | | | | | | 7 |
| 77.2 | 96.1 | 100 | | | | | | | | | | | 8 |
| | | | 10.2 | 22.5 | 35.2 | 49.6 | 70.3 | 73.7 | 80.5 | 87.7 | 88.1 | 100 | 10 |
| 80.0 | 83.0 | 96.2 | 100 | | | | | | | | | | 11 |
| 96.6 | 97.3 | 100 | | | | | | | | | | | 10 |
| 72.2 | 79.6 | 93.8 | 96.3 98.1 | 100 | | | | | | | | | 9 |
| 75.0 | 87.0 | 98.0 | 100 | | | | | | | | | | 9 |

together with such other species (types) that secure a more complete co-flowering. According to SMITH and KENDALL (1975), one-two types flowering earlier can be definitely advantageous in the orchard, since they will attract bees into the orchard before the flowering of the main variety begins.

**Table 5**

*Groups of flowering periods in Malus species (types) (Soroksár 1977–1978)*

| Very early | Mid-early | Mid-late | Very-late |
|---|---|---|---|
| SBK-1 | SBK-6 | SBK-5 | SBK-4 |
| SBK-9 | SBK-7 | SBK-8 | |
| | SBK-336 | SBK-1003 | |
| | | SBK-1014 | |
| | | Jonathan | |
| | | Starking | |

### *Flowering together with the Jonathan and Starking varieties:*

The species (types) flowering together with the main variety can most accurately be chosen on the basis of the flowering phenograms constructed from the flowering dynamics data. The areas below the curve determined by the percentage ratio of the open flowers in the flowering phenogrammes mark the rate of flowering correspondence reliably.

On the basis of the rate of flowering together, four groups were formed (flowering together up to the extent of 0–30, 30–50, 50–70 and 70–100%). The data obtained in 1978 are given in Table 6. An overlapping greater then 50% was found in the case of 3 species (types) with Jonathan, and in 2 species (types) with Starking (Figs 3 and 4). These species (types) also belonged to the groups of flowering period identical with that of the main varieties (Table 5).

**Table 6**

*Corresponding periods of flowering in Starking and Jonathan apple varieties with various Malus species (types) (Soroksár 1978)*

| Rate of corresponding flowering | Jonathan I | Jonathan II | Starking A | Starking B |
|---|---|---|---|---|
| 0– 30% | SBK-9 | SBK-9 | SBK-4 | SBK-4 |
| | SBK-1 | SBK-10 | SBK-336 | SBK-336 |
| | SBK-731 | SBK-731 | SBK-6 | SBK-6 |
| | SBK-3 | SBK-6 | SBK-7 | SBK-7 |
| | SBK-7 | SBK-4 | SBK-3 | SBK-3 |
| | SBK-6 | SBK-336 | SBK-1 | SBK-1 |
| | | | SBK-731 | SBK-10 |
| | SBK-4 | | SBK-10 | SBK-9 |
| | SBK-336 | | SBK-9 | |
| 30– 50% | SBK-8 | SBK-1 | SBK-5 | SBK-5 |
| | | SBK-3 | SBK-1003 | |
| | | SBK-7 | | |
| 50– 70% | | SBK-8 | — | SBK-1003 |
| 70–100% | SBK-1003 | SBK-1003 | SBK-8 | SBK-8 |
| | SBK-5 | SBK-5 | | |

In the "*Malus* pollination scheme" we have to try to achieve the fullest possible overlapping in the period of flowering of the pollinator and of the individuals to be pollinated. In the interests of secure pollination, two species (types) at least should be planted together with the variety to be pollinated. In this case, the flowers formed on both the one-year old canes and the several-year old sprigs will have pollinators flowering in correspondence with the flowers of the varieties. Taking into consideration the flower-visiting habit of the bees, we can suggest as pollinators primarily those species (types) whose flower petals are similar to those of Jonathan and Starking, that is, white and pinkish (SMITH–KENDALL 1975, JONKERS
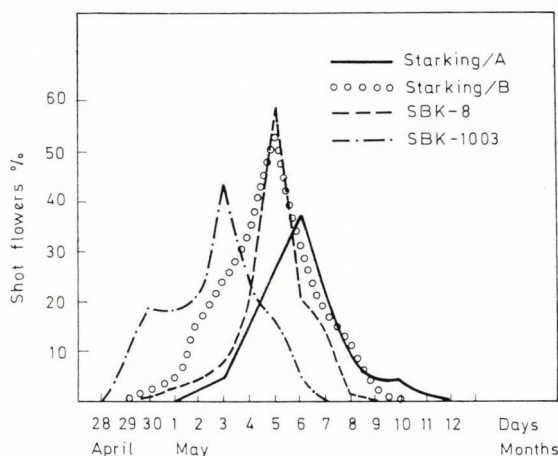
*Fig. 3. Malus* species (types) whose period of florescence corresponds with that of Jonathan apple varieties at a rate above 50% (Soroksár 1977)

et al. 1978). Of the species (types) examined by us, species (types) SBK-2 and SBK-8 have petals of vivid pink colour; SBK-1, SBK-3, SBK-9 and SBK-10 have light pink petals; further species (types) have white petals. The vivid (reddish) flower colour is not favourable because the bees will primarily visit only these flowers and will not fly over to the flowers of the main variety.

Growth characteristics:

*Malus* species (types) can be used as pollinators most economically if they are planted in the orchard without any special space requirement. Therefore, in intensive orchards, *Malus* species (types) of medium growth strength and of favourable foliage habit can be used. The situation is the same in the case of grafting on varieties. The growth characteristics given in
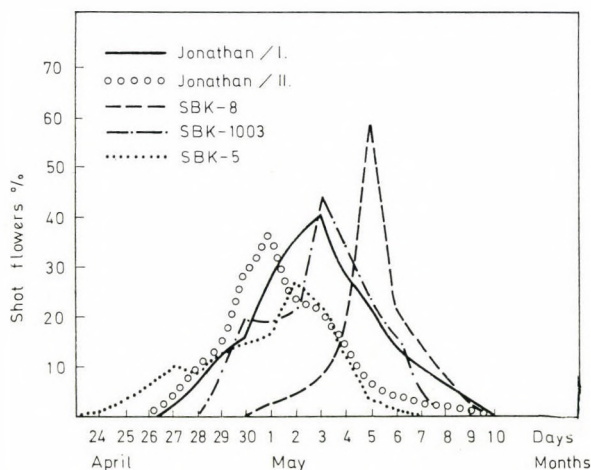
*Fig. 4. Malus* species (types) whose period of flowering corresponds with that of Jonathan apple varieties at a rate above 50% (Soroksár 1978)

Table 7 are only as a guide, for growth characteristics can only be pointed out reliably in model orchards, by grafting on suitable stocks and by making observations during the life of the orchard.

**Table 7**

*Growth characteristics of Malus species (types), on the basis of their usefulness in intensive apple orchards (Soroksár 1977)*

| Very strong growth | Favourable habitat | Pendula type |
|---|---|---|
| SBK-336 | SBK-1014 | SBK-1 |
| SBK-333 | SBK-1003 | SBK-9 |
| SBK-5 | SBK-731 | SBK-6 |
| | SBK-730 | |
| | SBK-726 | |
| | SBK-280 | |
| | SBK-277 | |
| | SBK-3 | |
| | SBK-7 | |
| | SBK-2 | |
| | SBK-10 | |
| | SBK-4 | |
| | SBK-8 | |

## Discussion

The use of *Malus* species as pollinators raises the possibility of planting single-variety apple orchards, which are more advantageous from technological and workshop-organizational viewpoints than the multi-variety orchards, for the single variety of the orchard can be provided with optimal agrotechnical control. The "*Malus* pollination scheme" as a possibility of continuing development comprises not only this technological solution. *Malus* species as pollinators can be used in a variety of solutions as follows:

— planting one variety and pollinator *Malus* species mixed in the orchard;
— planting *Malus* species in multi-varietal apple orchards, in broad variety blocks, as supplementary pollinators;
— complete or partial grafting of *Malus* species on individual trees in apple orchards with unfavourable pollination or in single-variety apple orchards;
— planting out *Malus* species, cultivated in culture vessels, for the period of flowering into single-variety orchards or into multi-variety orchards with unfavourable conditions of pollination;

— providing pollen for artificial pollination (independently; mixed with other *Malus* species or with conventional pollinators) in single-variety orchards;
— artificial supplementary pollination in orchards with unfavourable pollination conditions.

Correspondence in the flowering of *Malus* species with that of the varieties is only one and not the only requirement in using *Malus* species as pollinators. From the viewpoints of planting possibilities in the orchard, the growth characteristics are important for us to be known. Moreover, only those *Malus* species can be used as pollinators which are able to fertilize the varieties to a satisfactory extent (Soltész et al. 1979). It is a further important requirement for *Malus* species that the variety value, the quality of the fruits originating from the hybridization should be characteristic of the variety. The knowledge of flower colour, insect frequentation, virus-free condition, immunity from viruses, sensitivity towards bacteria, etc. as supplementary conditions, cannot be considered negligible.

It is only by considering all the requirements that we can choose the *Malus* species (types) which are usable in the *Malus* pollination scheme under the conditions of cultivation in Hungary. For this many years of research are needed for including several new types in our examinations. Within the flowering biological questions, our observations will be extended to the assessment of effective pollen quantity, insect frequentation colour of flower, flower sensitivity to freeze and the assessment of growth characteristics together with the graft effect.

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# EAST AFRICAN BRYOPHYTES, VI. POLISH COLLECTIONS

R. OCHYRA[1] and T. PÓCS[2]

[1] BOTANICAL INSTITUTE, POLISH ACADEMY OF SCIENCES, KRAKÓW, POLAND
[2] RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT

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During the years 1975–76 Polish East African Expedition "Kilimanjaro 76" collected bryophytes at several localities in Kenya, Tanzania, Uganda, Sudan and in Central African Republic. Other Polish collections, mainly from Zambia, are also added. An annotated list of 176 species including 48 liverworts and 128 mosses is provided. For each species list of localities, ecological and bryogeographical data, and taxonomic annotations are given. Several species are reported for the first time from particular regions, and *Amblystegium serpens* is new to the tropical Africa. The authors proposed the following new combinations: *Schistidium perichetiale* (P. Varde) Ochyra comb. nov.; *S. angustissimum* (P. Varde) Ochyra comb. nov.; *S. cribrodontium* (Herz.) Ochyra comb. nov.; *Schizomitrium africanum* (Mitt.) Ochyra comb. nov.; *S. applanatum* (Broth. et Bryhn) Ochyra comb. nov.; *S. ascensionis* (C. Muell.) Ochyra comb. nov.; *S. attenuatum* (C. Muell.) Ochyra comb. nov.; *S. brevipes* (Broth.) Ochyra comb. nov.; *S. chevalieri* (Broth. in Corb.) Ochyra comb. nov.; *S. chionophyllum* (C. Muell.) Ochyra comb nov.; *S. constrictum* (C. Muell.) Ochyra comb. nov.; *S. emarginatulum* (Broth. in Corb.) Ochyra comb. nov.; *S. eroso-truncatum* (Card.) Ochyra comb. nov.; *S. fissidentellum* (Besch.) Ochyra comb. nov.; *S. gabonense* (Broth. et P. Varde) Ochyra comb. nov.; *S. lacerans* (C. Muell.) Ochyra comb. nov.; *S. laeviusculum* (Mitt.) Ochyra comb. nov.; *S. leptocladulum* (C. Muell. ex Broth.) Ochyra comb. nov.; *S. maclaudii* (Par. et Broth.) Ochyra comb. nov.; *S. papillosulum* (Broth. et P. Varde) Ochyra comb. nov.; *S. parvocellulatum* (Demar. et P. Varde) Ochyra comb. nov.; *S. perpapillatum* (Broth. et P. Varde) Ochyra comb. nov.; *S. perrotii* (Par.) Ochyra comb. nov.; *S. pusillum* (Broth. ex Demar. et P. Varde) Ochyra comb. nov.; *S. salaziae* (Besch.) Ochyra comb. nov.; *S. seychellense* (Besch.) Ochyra comb. nov.; *S. subemarginatulum* (Broth. et P. Varde) Ochyra comb. nov.; *S. triste* (C. Muell.) Ochyra comb. nov.; *S. usambaricum* (Broth.) Ochyra comb. nov.; *Schizomitrium* sect. *Convergentes* (Demar. et P. Varde ex Demar.) Ochyra comb. nov.; *Schizomitrium* sect. *Rectae* (Demar. et P. Varde ex Demar.) Ochyra comb. nov.; *Schizomitrium* sect. *Divergentes* (Demar. et P. Varde ex Demar.) Ochyra comb. nov.; *Homalothecium afro-striatum* (C. Muell.) Ochyra stat. et comb. nov.; *Kindbergia africana* (Herz.) Ochyra comb. nov.; *K. africana* var. *latifolia* (Demar. et Leroy) Ochyra comb. nov.; *Hypnum africanum* (P. Varde) Ochyra comb. nov.; *Guembelia abyssinica* C. Muell. and *Grimmia abyssinica* (C. Muell.) Jaeg. are reduced to synonymy of *G. apiculata*.

## Introduction

On the turn of the 1975/1976 under the auspicies of the Jagiellonian University and Polish Tourist Society was arranged a Polish scientific and climbing expedition "Kilimanjaro 76" to East Africa. The expedition focused chiefly at the highest East African mountains in Kenya and Tanzania (Mt. Kenya, Mt. Elgon, Mt. Meru, Kilimanjaro Mts.). Moreover, some other places including Serengeti National Park and Ngorongoro Conservation Area in Tanzania and Ol Doinyo Sapuk National Park in Kenya were visited. In the return way the Expedition has dwelt in Uganda, Sudan and in Central African Republic.

*Fig. 1.* Mt. Kenya, Sirimon track: view on the summit part of Mt. Kenya from the slopes of The Barrow, at 3900 m alt. On the first plan *Lobelia telekii* and tussocks of *Festuca pilgeri.* Phot. K. STRZAŁKA. Locality of *Andreaea cucullata, Ceratodon purpureus, Campylopus stramineus, Leptodontium joannis-meyeri, Tortula cavallii, Rhacomitrium alare, Funaria perlaxa, Hedwigidium integrifolium, Homalothecium afro-striatum, Polytrichum commune* and *P. piliferum*

During the Expedition a collection of bryophytes has been made consisting of approximately 600 specimens of liverworts and mosses. Most of the collections were made in Kenya and Tanzania, and additional ones in Uganda, Sudan and in Central African Republic. The bryophytes were collected mainly by a zoologist from the Jagiellonian University, Dr. S. ROJKOWSKI, and only small samples were gathered by the other members of the Expedition: Prof. J. KORNAŚ and Drs. K. SZCZEPANEK and B. ZEMANEK. Professor KORNAŚ also submitted a bryophyte material collected by himself and by his family members in Zambia during 1972–1973. We express our kindest gratitude for delivery of these collection for identification by ourselves. This resulted in a list consisting of 48 liverworts and 126 moss species. Some of them represent new records for the particular regions, and some are rare species which have been previously collected a few times only. Amblystegium serpens was collected for the first time in tropical Africa.

Most determinations of mosses have been made by R. OCHYRA, and only some taxa were named by Prof. J. L. DE SLOOVER of Namur, Belgium. He confirmed also some determinations made by R. OCHYRA. We express to him our kindest gratitude. We receive important materials for comparison from PC and NY, and we are much indebt to the directors and curators of these herbaria for their assistance. The Hepaticae were identified by T. PÓCS, who also provided a few distributional maps.

In the list of species after a consecutive number and species name we give in some cases important or new synonyms, ecological and bryogeographical data and localities of collected specimens. New records for a larger geographical unit are marked with an asterisk before its abbreviation. The numbers in parentheses are referred to the collection made by

*Fig. 2.* Mt. Kenya, Sirimon Track: Hut Tarn; on the first plan *Lobelia telekii* and *Senecio keniodendron*; in the background Point John (right) and the massif of Nelion (left). The photo was made at 4500 m alt. by K. Strzałka. Locality of *Grimmia affinis*, *G. trichophylla*, *Schistidium perichaetiale*

Dr. S. Rojkowski. Other collector's names are abbreviated as follows: K — Jan Kornaś, Anna Medwecka-Kornaś and Maria Kornaś; SZ — K. Szczepanek and B. Zemanek. The collecting data are followed by the abbreviated name of the identifier: O — R. Ochyra, P — T. Pócs, DS — J. L. De Sloover. Short remarks on the general geographical distribution are also provided. In some cases taxonomic problems are discussed. The publication of the species in the previous papers of "East African Bryophytes" series (Bizot and Pócs 1974; Bizot et al. 1976; Bizot and Pócs 1979; Bizot et al. 1978; Bizot et Pócs 1982) is indicated by the abbreviation EAB I, II, III, IV, V, respectively.

The first set of moss specimens is preserved in KRAM-B, duplicate sets are deposited in EGR and in NAM; liverworts are preserved in EGR and their duplicate set in KRAM-B. Moreover, numerous duplicates have been distributed to the various herbaria of the world and some species were edited by J. L. De Sloover in his "Herbier Bryologique".

Abbreviations of the geographical units used in the text:

| | | | |
|---|---|---|---|
| ELG: | Mt. Elgon | RCA: | Central African Republic |
| K: | Kenya | SUD: | Sudan |
| KEN: | Mt. Kenya | T: | Tanzania |
| KIL: | Kilimanjaro Mts. | UGA: | Uganda |
| MER: | Mt. Meru | Z: | Zambia |

### List of species collected

## HEPATICAE

### Blepharostomaceae

1. **Blepharostoma trichophyllum** (L.) Dum. — *KEN: Sirimon Track, on soil among *Jungermannia abyssinica*, 3600 m (148b); det. P. Northern temperate species, altimontane in Africa, new to Kenya. EAB I, III.

### Lepidoziaceae

2. **Lepidozia truncatella** Nees — KIL: Marangu Route near Mandara Hut, 2730 m (290d); det. P. East African montane — South African species, EAB III.
3. **Lepidozia stuhlmannii** Steph. — *MER: on bark, at 2700 m. Afromontane–afroalpine species.
4. **Arachniopsis diacantha** (Mont.) Howe — *Z: Northern Prov., Chinsali Distr., Chipoma Falls 20 km S of Chinsali, 1350 m, on soil (K 0048b); det. P. EAB I, III, new to Zambia.
5. **Telaranea nematodes** (Gott. ex Aust.) Howe — *Z: Chinsali Distr., Chipoma Falls, fringing forest, 1350 m K (0058a); det. P. Oceanic cosmopolite, widespread in tropical and in South Africa, new to Zambia.

### Cephaloziellaceae

6. **Cylindrocolea atroviridis** (Sim) Váňa — *RCA: Bangui, on palm stem, intermixed among *Acrolejeunea emergens* and *Lejeunea rhodesiae* (449b, 450b); det. P. Previously known from Nigeria, Rwanda, Tanzania and Natal, new for RCA.

### Jungermanniaceae

7. **Andrewsianthus bilobus** (Mitt.) Grolle — *MER: 2700 m, on bark (338b); det. P. Afromontane species.
8. **Jungermannia abyssinica** Nees in Gott. — KEN: Sirimon Track, on ground, together with *Funaria perlaxa* Thér, 3600 m (148a); det. P. Afroalpine species known from Uganda, Ethiopia, Kenya and Tanzania, between 1500–4000 m.
9. **Jungermannia borgenii** Gott. — Z: NW Prov., Zambezi source near Mwinilunga, on bark in moist evergreen forest (K 0020c); det. P. Widespread afromontane species.

### Geocalycaceae

10. **Lophocolea lucida** (Spreng. ex Lehm.) Mont. — *Z: Northern Prov., Chinsali Distr., Chipoma Falls, on ground, 1350 m (K 0048a); det. P. Afromontane species also in South Africa and in the neighbouring islands, EAB I, III.

11. **Lophocolea concreta** Mont. — Z: NW Prov., Zambezi Source near Mwinilunga, on bark in moist evergreen forest, 1580 m (K 0024b); det. P. Widespread in tropical Africa, EAB I, III, IV.

### Plagiochilaceae

12. **Plagiochila barteri** Mitt. — *KIL: Marangu Route near Mandara Hut, 2730 m (278, 291c, 290b); det. P. Widespread afromontane species.
13. **Plagiochila colorans** Steph. in Mildbr. — KIL: Marangu Route near Mandara Hut, on bark and on ground, 2730 m (289b, 300a); det. P. Afroalpine species, EAB IV.
14. **Plagiochila divergens** Steph. — T: Serengeti N. P., Naabi Hills Gate, on bark (215); Ngorongoro Crater rim, on bark 2500 m (240, 244, 251, 260); KIL: Marangu Route, on bark 1800–2730 m (276, 303, 289a) the last two: var. **myriocarpa** (Pears) E. W. Jones; Z: NW Prov., Zambezi source near Mwinilunga, on bark in moist evergreen forest (K 0020b); N Prov., Mporokoso Distr., Kolungwashi River, Lumangwe Falls, 1020 m (K 0080b); K: *Eldoret, on bark 2450 m (28); *Nairobi — Uhuru Highway, on bark (14); det. P. Afromontane, EAB I, III, IV.
15. **Plagiochila ericicola** Steph. — KIL: Marangu Route near Mandara Hut, terricolous, 2730 m (300b); det. P. Afroalpine, EAB I, III.
16. **Plagiochila effusa** Steph. — *K: Ol Doinyo Sapuk National Park, 2340 m (414b); T: *Ngorongoro Crater rim 2500 m (233a); det. P. Widespread afromontane species, EAB I.
17. **Plagiochila fusifera** Tayl. — *K: Ol Doinyo Sapuk Nat. Park 2340 m, corticolous 401, 406; *Z: NW Prov., Zambezi source near Mwinilunga, 1580 m (K 0021); det. P. Widespread in tropical Africa, EAB I, IV.
18. **Plagiochila lastii** Mitt. — KEN: Sirimon Gate, corticolous, 2550 m (186); KIL: Marangu Route below Horombo Hut, on bark, 3500 m (318b); det. P. East African montane species, EAB II, IV.
19. **Plagiochila praemorsa** Steph. — *UGA: Kampala, corticolous (407a); det. P. Tropical African species new to Uganda.
20. **Plagiochila squamulosa** Mitt. var. **squamulosa** — *ELG: Corticolous in Hagenia-Hypericum forest at 2200–3000 m (33, 40a, 42b); *KEN: Sirimon Gate — Sirimon Track 2550–2600 m, on bark (167, 180b); det. P.

    — var. **crispulo-caudata** (Gott.) Vanden Berghen — *KEN: Sirimon Gate, corticolous in Podocarpus forest, 2550 m (180a, 189); T: Ngorongoro Crater rim, on bark, 2500 m (252a); MER: E, 2700 m, on bark (373); Z: Northern Prov., Mbala Distr., Mt. Sunzu, 2010 m, corticolous in open woodland (K 0076e); det. P.

    — var. **sinuosa** (Mitt.) Vanden Berghen — ELG: S 2200 m, on bark (36, 39c); K: Ngong Hills near Nairobi, ramicolous, 2450 m (200a, SZ); KEN: Sirimon Gate and Track, 2600 m (173c, 177a, 184, 187); K: Nakuru-Rongai, Deloraine Farm, 1800 m (coll. ?); *Z: Northern Prov., Mbala Distr., Mt. Sunzu, rupicolous, 1580–2030 m (K 0071, 0073); det. P. The above records seem to confirm Vanden Berghen's concept (1981: 74–75), who united the three species at variety level. Their differences are not sharply limited and according to the new records they are not isolated geographically, as it was thought by Jones (1962: 283–288), although he himself expressed his doubt about the distinction of the species (l.c. 287).
21. **Plagiochila strictifolia** Steph. — *Z: NW Prov., Zambezi rapids 2.5 km above Zambezi bridge on the Mwinilunga — Angola Road, corticolous, 1300 m (K 0027b); det. P. Tropical African lowland species distributed mainly in West Africa.
22. **Plagiochila** cf. **terebrans** Ldbg. — KIL: Marangu Route near Mandara and Horombo Huts, 2750–3500 m, corticolous (290, 317); det. P. Atypical form, with almost iso-

diametric cells and with less conspicuously thickened walls. E. W. JONES (1962: 308) also mentions such variation. Widespread afromontane species.

### Acrobolbaceae

23. **Lethocolea congesta** (Lehm.) S. Arn. — KIL: Marangu Route, near Horombo Hut, terricolous, 3700 m (334); det. P. Afroalpine + South Africa, East African islands, and Tristan da Cunha, EAB I, III, IV.

### Radulaceae

24. **Radula holstiana** Steph. — KIL: Marangu Route, below Horombo Hut, corticolous, 3500 m (318a); det. P. Widespread afromontane species, EAB I, III (see Fig. 3).
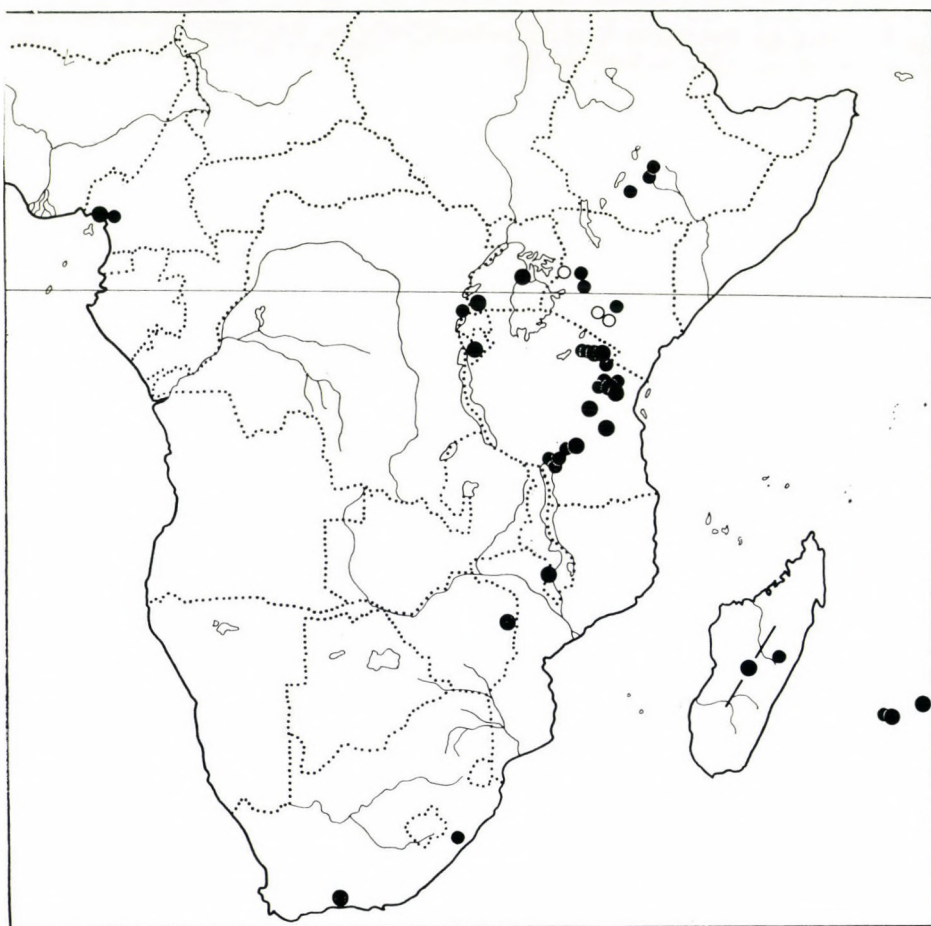
*Fig. 3.* The range of two afromontane elements, with almost equal distribution, one of them restricted to more humide habitats (*Radula holstiana*, large dots), the other distributed in more xeric environments (*Radula recurvifolia*, smaller dots)

25. **Radula recurvifolia** Steph. — *ELG: S 2200–3100 m, Hagenia-Hypericum forest, on bark (39a, SZ); K: *Ol Doinyo Sapuk Nat. Park, corticolous, 2340 m (391, 397a); *Ngong Hills near Nairobi, on bark (199); T: Ngorongoro Crater rim, 2500 m (233b); det. P. Afromontane species, EAB I, IV (see Fig. 7).

### Porellaceae

26. **Porella abyssinica** (Nees) S. Arn. — MER: E 2700 m, on bark (349); det. P. East African montane species, EAB I, IV.
27. **Porella hoehnelii** Steph. — ELG: corticolous in Hagenia-Hypericum forest, 3000 m (42b); KEN: Sirimon Track, 2600 m, corticolous (173a, 177b, SZ); det. P. East African montane species + S Africa and Madagascar. EAB I, IV.
28. **Porella subdentata** (Mitt.) E. W. Jones var. **subdentata** — K: Nyeri, on roadside trees (86); T: Ngorongoro Crater rim, 2500 m, corticolous (252b); KIL: Marangu Route, 2730 m, corticolous (302); *Z: NW Prov., Zambezi source near Mwinilunga, 1580 m (K 0019a); det. P. Widespread tropical African species, EAB I, IV.

### Jubulaceae

29. **Frullania angulata** Mitt. — *UGA: Kampala, corticolous (407); det. P. Widespread afromontane species, EAB I, IV.
30. **Frullania arecae** (Spreng.) Gott. — K: Ngong Hills, ramicolous (200b); det. P. Widespread pantropical species, EAB I, II, IV.
31. **Frullania caffraria** Steph. — ELG: 2200 m, on bark (40b); K: Nakuru — Rongai, Deloraine Farm, on bark, 2000 m; T: Serengeti Nat. Park, Naabi Hills Gate, corticolous (214); det. P. Widespread from Ethiopia to Cape, EAB I, IV.
32. **Frullania depressa** Mitt. — ELG: 3000 m (47); K: Eldoret, in Acacia grove, ramicolous and corticolous, 2450 m (20, 21b); Serengeti Nat. Park, Naabi Hills Gate, on bark (218a, 224); Ngorongoro Crater rim, 2500 m, on bark (245); KIL: terricolous near Mandara Hut, 2730 m (229); det. P. Widespread in tropical Africa, EAB III, IV.
33. **Frullania ericoides** (Nees) Mont. — RCA: Zemio, on palm stem (437a, 443a); Bangassou (445a); UGA: Kampala (417a, 424); *ELG: S 2200 m, on bark 35a, 38, 39b; K: Kariandusi between Nakuru and Naivasha, corticolous (81a); det. P. Common pantropical species.
34. **Frullania trinervis** (Lehm. et Lindenb.) Gott. et al. — RCA: Bangassou, on palms (445b); UGA: Kampala, corticolous (417b); K: Nairobi, Uhuru Highway, corticolous (15, 16); *Z: Central Prov., Kasisi, in dense woodland, 1130 m (K 0087); Lusaka, Chelston, 1230 m, corticolous (K 0088); det. P. Widespread in tropical and in South Africa. EAB I, III, IV.

### Lejeuneaceae

35. **Acrolejeunea emergens** (Mitt.) Steph. — RCA: Bangui, on palm stem 450a; Zemio, on palms (437b, 443b); det. P. Widespread in tropical America and Africa.
36. **Marchesinia excavata** (Mitt.) Steph. — Z: NW Province, Zambezi rapids 2.5 km above Zambezi Bridge on the Mwinilunga — Angola Road, in evergreen fringing forest, 1300 m (K 0027b); det. P. Widespread in tropical Africa, EAB IV.
37. **Ptychanthus striatus** (Lehm. et Lindenb.) Nees — T: Ngorongoro Crater rim, on bark, 2500 m (240); Z: Northern Prov., Mporokoso Distr., Kalungashi River, Lumangwe Falls, on bark, 1020–1170 m (K 0077, 0078); det. P. Widespread palaeotropical element, EAB I, III.

38. **Lejeunea caespitosa** Lindb. — *K: Nairobi, Uhuru Highway, on bark (17a); det. P. Widespread in tropical Africa and America, EAB I.
39. **Lejeunea flava** (Sw.) Nees ssp. **flava** — *UGA: Entebbe near Kampala, on bark 432; det. P.
    — ssp. **tabularis** S. Arnell — *K: Ol Doinyo Sapuk Nat. Park, 2340 m, on bark (413b); *KIL: Marangu Route near Mandara Hut, 2730 m (291a); det. P. Pantropical species with tropical African subspecies.
40. **Lejeunea helenae** Pears. — *UGA: Entebbe near Kampala, rupicolous (427); det. P. Rare afromontane species, EAB III.
41. **Lejeunea isophylla** E. W. Jones — KIL: Marangu Gate, on bark, 1800 m (284); det. P. Widespread afromontane species, EAB I, III, IV.
42. **Lejeunea rhodesiae** (Sim.) E. W. Jones = **Rectolejeunea rhodesiae** (Sim.) S. Arn. — RCA: Bangui, on palm stem (449a); UGA: Kampala, on wall of a house (422); det. P. Widespread in tropical Africa.
43. **Lejeunea ulicina** (Tayl.) ssp. **ocellifera** (S. Arn.) Schust. (= *Microlejeunea africana* Steph.) — KIL: Marangu Route near Mandara Hut, 2730 m (291b); det. P. Tropical African subspecies, EAB I, II, III, IV.
44. **Rectolejeunea brittonae** Evans (= *R. arnellii* E. W. Jones) — *KEN: Sirimon Track, lignicolous, 3300 m (234); det. P. Species known from the Caribbean region: Cuba, Bahamas, Florida and from the East African mountains from the Mt. Meru to the Southern Highlands of Tanzania and from Cape.

### Aneuraceae

45. **Riccardia limbata** (Steph.) E. W. Jones — *Z: Northern Prov., Chinsali Distr., Chipoma Fall 20 km S of Chinsali, 1350 m, lignicolous (K 0045); det. P. Widespread in tropical and in South Africa.

### Metzgeriaceae

46. **Metzgeria agnewii** Kuwah. — *K: Ngong Hills, ramicolous (200c); det. P. East African montane species, EAB III, IV (see Fig. 4).
47. **Metzgeria limbato-setosa** Steph. — K: *Ol Doinyo Sapuk Nat. Park 2340 m, lignicolous (390, 397b, 398, 399, 400, 403, 406, 413, 414); *ELG: S 2200 m, corticolous (39d); KIL: Marangu Gate, corticolous, 1800 m (275); UGA: Kampala, corticolous (407b); det. P. East African montane species, EAB I, III, IV.
48. **Metzgeria thomeensis** Steph. — K: *Ol Doinyo Sapuk Nat. Park, corticolous, 2340 m (412); det. P. Widespread tropical African species, EAB I, III, IV.

## MUSCI

### Andreaeaceae

49. **Andreaea cucullata** Dix. in Herz. — Rupicolous in subalpine and alpine zones. KEN: Sirimon track, near Liki North Hut, 3900 m (144); det. O. Rare afroalpine species known from Kilimanjaro, Mt. Meru, and Mt. Kenya at altitude 3300–5000 m. EAB IV.
50. **Andreaea mildbraedii** Broth. in Mildbr. — Rupicolous in alpine zone. KEN: Sirimon track, above Liki North Hut, 4200 m (162); det. O. Widely distributed afroalpine species known from all the high mountains in East African volcanic area occurring between 3200 and 5000 m. EAB IV.
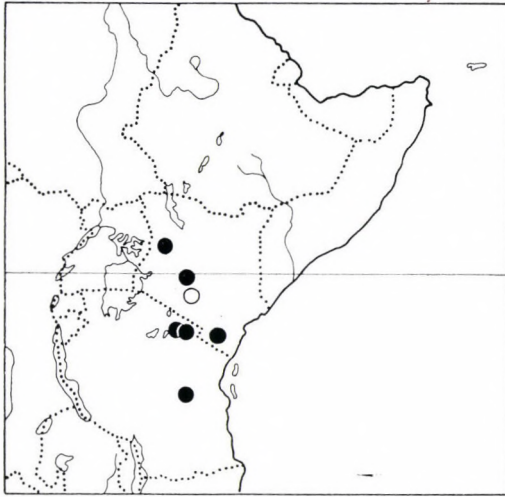
*Fig. 4.* Distribution of an East African montane element with narrow range: *Metzgeria agnewii.* Black dots represent previously known, open rings new records, here and on the following maps as well

**Fissidentaceae**

51. **Fissidens angolensis** Welw. et Duby — *UGA: Kampala, on soil at tree base (419); det. O. Uncommon species in tropical Africa known from Angola, Kenya and Tanzania (Usambara Mts., Kilimanjaro Mts.). New to Uganda. EAB II, III, IV.
52. **Fissidens glaucescens** Hornsch. — ELG: SE slope of the crater rim, on humus in rock crevices, 3900 m; coll. SZ, det. O. Widespread in South and East Africa. It is closely related to the pantropical *Fissidens asplenioides* which is very common in tropical Africa. *F. amblyophyllus,* treated as conspecific with *F. glaucescens* (DIXON and GEPP 1923) is definitely identical with *F. asplenioides,* fide MAGILL and SCHELPE (1979: 27).

**Ditrichaceae**

53. **Ceratodon purpureus** (Hedw.) Brid. — KEN: Sirimon track, on wet rocks below Liki North Hut, 3800 m (110); in moist situation on riverbanks, 4300 m (163); det. O. Cosmopolitan species, altimontane in tropical Africa occurring between 2000 and 4650 m. EAB I, III, IV.

**Dicranaceae**

54. **Dicranoweisia africana** Dix. — KIL: Marangu route, near Horombo Hut, on rocks, 3760 m (310); det. DS. Rare afroalpine species occurring between 3200 and 4000 m on Mt. Elgon, Mt. Meru and on Kilimanjaro.
55. **Campylopus jamesonii** (Hook.) Jaeg. Syn.: *Campylopus procerus* (C. Muell.) Kindb. fide FRAHM 1980: 216–217. — Terricolous and epixylic in subalpine woodland and in ericaceous heath. KIL: Marangu route, below and near Mandara Hut, 2500–2750 m (273b, 281, 301); near Horombo Hut, 3500 m (336a); det. O. Widespread montane-afroalpine species occurring between 1800 and 4000 m from Cameroon to Transvaal, and in Central and South America from Guatemala to Bolivia growing at similar alti-

tudes. EAB I, III (as *C. procerus*). World distribution map of this species was provided by FRAHM (1980).

56. **Campylopus pilifer** Brid. — Terricolous in montane forests. MER: W slope of the crater rim, 2700 m (343); KIL: Marangu route, near Mandara Hut, 2700 m (286); det. O. Pantropical — warm temperate species widespread in wetter parts of tropical Africa from lowlands to subalpine zone. EAB I, II, IV (as *C. introflexus* var. *polytrichoides*, *C. polytrichoides*), III.

57. **Campylopus stramineus** (Mitt.) Jaeg. — Terricolous and epixylic in montane forests. — ELG: SE slope of the crater rim, 4100 m (57); KEN: Sirimon track, near Sirimon Gate, 2600 m (161); near Liki North Hut, 3800–3900 m (109, 121, 127); MER: W slope of the crater rim, montane rain forest, 2700 m (337); KIL: Marangu route, near Mandara Hut, 2700 m (282); near Horombo Hut, 3700–3760 m (309, 324); det. O. Highly variable (fide BIZOT and KILBERTUS 1979) afromontane species occurring from Cameroon to South Africa at altitude 2900–4500 m. EAB I, III, IV.

58. **Dicranum johnstonii** Mitt. — KIL: Marangu route, corticolous, near Horombo Hut, 3500 m (336); det. O. Widely distributed East African montane species (Ruwenzori, Kilimanjaro, Kenia, Aberdare, Ukaguru, Usambara Mts., etc.) where it occurs at altitude 1800–4000 m. EAB I, III, IV.

59. **Leucoloma holstii** Broth. — Corticolous in montane forests. KIL: Marangu route, below Mandara Hut, 2500–2700 m (273, 279, 285); det. DS. Widespread East African afromontane species occurring usually between 900 and 2700 m. EAB I, II, III, IV.

### Calymperaceae

60. **Calymperes palisotii** Schwaegr. var. **palisotii** — Corticolous on palms. *RCA: Zemio (441); Bangassou (444); Bangui (452); det. O. Widespread in West and Central Africa but EDWARDS (1980) does not mention any localities of this species in Central African Republic.

### Leucobryaceae

61. **Octoblepharum albidum** Hedw. — RCA: Bangui, corticolous on palm (457); det. O. Z: NW Prov., Zambezi source near Mwinilunga, on bark in moist evergreen forest, 1580 m (K 0020e); det. P. Pantropical, widespread in tropical Africa. EAB I, IV. See the map of EGUNYOMI (1978).

### Pottiaceae

62. **Anoectangium euchloron** (Schwaegr.) Mitt. — K: Arusha, on wall of building by road, c. 1800 m (210); det. DS. Widespread pantropical species uncommon in tropical Africa.

63. **Trichostomum fragilifolium** Dix. — KEN: Sirimon track, on decaying wood near Sirimon Gate, 2550 m (193); det. O. Rare afromontane species known only from Mt. Kenya and from the Iringa Distr. in Tanzania.

64. **Leptodontium filicaule** Dix. — KEN: Sirimon track, on ground, 3300 m (103); det. O. Rare afromontane species known only from Mt. Kenya and Aberdare Mts.

65. **Leptodontium joannis-meyeri** C. Muell. — Terricolous and rupicolous in subalpine zone. ELG: SE slope of the crater rim, 3000–4000 m (44, 64); KEN: Sirimon track, below Liki North Hut, 3800–3950 m (112, 143, 169); KIL: Marangu route, near Horombo Hut, 3700–3800 m (313, 320, 328); det. O. Afroalpine species known from all the high mountains in East Africa growing between 3000 and 4000 m. EAB III.

66. **Leptodontium luteum** (Tayl.) Mitt. — Terricolous in montane rain forests and in ericaceous belt. KIL: Marangu route, near Mandara Hut, 2730 m (298); near Horombo Hut,

3500 m (335); MER: W slope of the crater rim, 2700 m (341); det. O. Altimontane species known in East Africa only from Mt. Meru, Mt. Kenya and from Kilimanjaro Mts. at altitude 2700–3500 m. Apart from Africa it is known to occur in Andes (Colombia, Peru, Bolivia, Ecuador) at similar altitudes. EAB I (as *L. volkensii*), III.

67. **Leptodontium pungens** (Mitt.) Kindb. — Terricolous and rupicolous in alpine zone. *ELG: SE slope of the crater rim, 3000 m (63); KEN: Sirimon track, 3300 m (93); det. O. Altimontane species in Africa known from Cameroon, Kenya, and Tanzania (Mt. Meru, Kilimanjaro Mts.); widespread in Central and South American Cordilleras from Mexico to Argentina. EAB IV.

68. **Leptodontium viticulosoides** (P. Beauv.) Wijk et Marg. — Epiphytic in submontane and montane forests. MER: W slope of the crater rim, 2700 m (344); KIL: Marangu route, below Mandara Hut, 2500 m (280); K: between Eldoret and Kitale, c. 1900 m (50); det. O. Pantropical montane species, widespread in tropical Africa. EAB I, III, IV.

69. **Hyophila baginsensis** C. Muell. — K: Likoni near Mombassa, on concrete wall (1, 4); det. O. Uncommon East African species occurring from Somali to Zimbabwe.

70. **Bryoerythrophyllum alpigenum** (Vent.) Chen — *ELG: SE slope of the crater rim, on rocks, 4000 m (67, 68); det. O. Widespread altimontane species, arctic–alpine on the Northern Hemisphere. In Africa previously known only from Ruwenzori and Kilimanjaro Mts. at altitude 3700–4000 m. EAB III.

71. **Streptopogon erythrodontus** (Tayl.) Wils. var. **rutenbergii** (C. Muell. ex Geh.) Salm. — Corticolous among other mosses in relatively dry montane forests. *ELG: SE slope of the crater rim, 2200 m (30a); det. DS; T: *Serengeti National Park, Naabi Hills, 1600 m (220, 230); det. O; K: *Ngong Hills near Nairobi, ramicolous (200c); det. P. This variety is widespread in submontane and montane regions of tropical Africa from Cameroon and Ethiopia to Tanzania occurring at altitude 1600–3500 m. EAB III, IV.

72. **Tortula cavallii** Negri — Corticolous and terricolous in subalpine and alpine zones. ELG: SE slope of the crater rim, 4000 m (62); KEN: Sirimon track, below Liki North Hut, 3800–3950 m (114, 116, 118, 123, 136, 137); det. O. and DS. Afroalpine species known from all the high mountains in East Africa. EAB III, IV (see Fig. 5).

73. **Tortula fragilis** Tayl. Syn.: *T. schmidii* (C. Müll.) Broth., *T. hildebrandtii* (C. Müll.) Broth. — Xerophytic, corticolous and terricolous. K: Kariandusi between Nakuru and Naivasha, c. 1800 m (83); det. DS; T: along the rim of Ngorongoro Crater, alt. c. 2200 m (236, 256); UGA: Kampala, on wall (423); det. O. T: Serengeti Nat. Park, Naabi Hills Gate, on bark (218b); det. P. Very widespread in the drier regions of Africa up to 4000 m altitude. Pantropical species occurring also in the warm temperate part of the Northern Hemisphere.

### Grimmiaceae

74. **Grimmia affinis** Hornsch. Syn.: *Grimmia ovalis* auct. afr. non (Hedw.) Lindb. Rupicolous. KEN: Sirimon track, 3600 m (96); above Liki North Hut, 4000–4300 m (132, 154); det. O. Widespread circumboreal species known also from the high altitudes of Ceylon and Central and South American Cordilleras. Because of nomenclatural and taxonomic entaglements between *Grimmia affinis* and *G. ovalis* (Hedw.) Lindb. the status of African populations of this complex was unclear. However, in the result of recent investigations of Sayre (1951) and Deguchi (1979) the distinction between both species in question was definitely solved. An examination of numerous collections from Africa deposited in PC and EGR showed that all East African records named *G. ovalis* belong in fact to *G. affinis*. This species is widespread in the high African mountains from Cameroon to South Africa being common in all the high mountains in East Africa
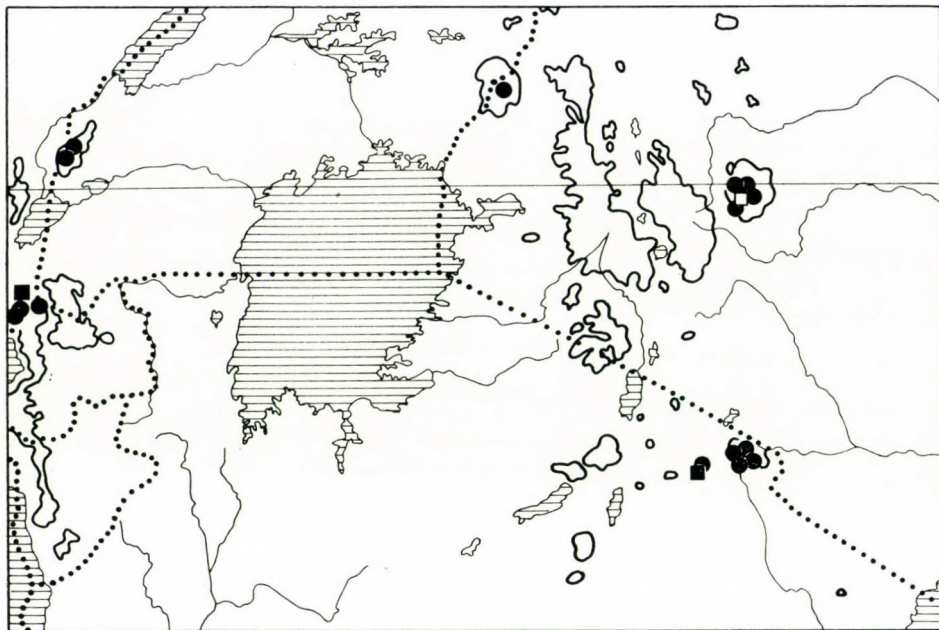
*Fig. 5.* Distribution of two afroalpine elements: *Tortula cavallii* (circle) and of *Funaria perlaxa* (square). Open square represents a new record

at altitude above 3300 m. *G. ovalis* is an uncommon species known only from South Africa. Annotation by O. EAB III, IV (as *G. ovalis*).

75. **Grimmia apiculata** Hornsch. **Syn. nov.:** *Guembelia abyssinica* C. Muell., *Grimmia abyssinica* (C. Muell.) Jaeg. — KEN: Sirimon track, below Liki North Hut, on boulders, 3900 m (142); det. O. In his original description of *Guembelia abyssinica* C. MUELLER (1849) compared this species to *G. apiculata* from which it differs mainly by its sexual condition. *G. abyssinica* was described as dioicous whereas *G. apiculata* is evidently an autoicous species. DEGUCHI (1979) stated, however, that perigonia in *G. apiculata* are located just below the perichetia and are hidden by vegetative leaves, and, therefore, they may be easily overlooked. Having examined an isotype of *Guembelia abyssinica* from the New York Botanical Garden (NY) I can confirm that SCHIMPER's plants collected on Mt. Silke in Abyssinia on February 18, 1840 and distributed in his Musci Abyssinici No. 435 are evidently autoicous. Similarly, all other examined African specimens named *G. abyssinica* were also autoicous. On the other hand, the original specimen in NY as well as other examined plants show all features that correspond well to the Holarctic specimens of *G. apiculata*. Accordingly, I put *G. abyssinica* into synonymy of *G. apiculata*. Thus, the total geographical range of *G. apiculata* being previously circumboreal extended into East Africa. *G. apiculata* show here altimontane distribution pattern occurring rarely from Ethiopia to northern Tanzania. Annotation by O.

76. **Grimmia laevigata** (Brid.) Brid. — Rupicolous in afroalpine zone. *KEN: Sirimon track, 3300 m (97a); KIL: Marangu route, near Horombo Hut, 3700 m (329); det. O. Subcosmopolitan species occurring in tropical Africa on Mt. Elgon, Mt. Kenya and in Kilimanjaro Mts., and common in South Africa.

77. **Grimmia trichophylla** Grev. var. **brachycarpa** De Not. Syn.: *Grimmia lisae* De Not., *G. trichophylla* subsp. *lisae* (De Not.) Boul., *G. trichophylla* var. *lisae* (De Not.) Luis., *G. trichophylla* var. *meridionalis* C. Muell. — Rupicolous in alpine zone. *ELG: SE slope of the crater rim, 4000 m (70); *KEN: Sirimon track, above Liki North Hut, 3900–4000 m (97b, 98, 106, 129, 130, 139, 153, 168); alt. 4800–5000 m, on boulders protruding in glacier (155, 157, 164); det. O. The variety is widely distributed in warmer parts of the Northern Hemisphere, and in tropical Africa it was previously known only from Kilimanjaro Mts. Some additional new records are from Mt. Elgon and Mt. Kenya where it seems to be common in alpine zone at altitude above 4000 m. EAB III.

78. **Schistidium perichaetiale** (P. Varde) Ochyra, **comb. nov.**
Basionymon: *Grimmia perichaetialis* P. Varde, Ark. Bot. 3 (8): 149. 10. 1955.
KEN: Sirimon track, on boulders protruding in glacier, 5000 m (165); det. O. Afroalpine species known only from Ruwenzori and Mt. Kenya where it occurs at altitude 4450–5000 m.

The genus *Schistidium* is well represented in moss flora of tropical Africa. Apart from the cosmopolitan *Schistidium apocarpum* and *S. confertum*, there are three additional species of the genus known to occur in the high mountains in East Africa. Unfortunately, they were not treated by Bremer (1980a, b, 1981) in her world-wide monograph of *Schistidium*. By the kindness of R. Baudoin I was able to examine the holotypes of the two species described by P. de la Varde (1955). Both are very distinct taxa not similar to any of the known species of this genus. The third species, *Grimmia cribrodontia*, was not yet studied by myself but according to the description and excellent drawing it is evidently different from the other East African species. Accordingly, the following new combinations should be made in the genus *Schistidium*:

**Schistidium perichaetiale** (P. Varde) var. **piliferum** (Demar. ex Demar.) Ochyra **comb. nov.**
Basionymon: *Grimmia perichaetialis* P. Varde var. *pilifera* Demar. ex Demar., Bull. Soc. Bot. Belg. 88: 92 (1956).

**Schistidium angustissimum** (P. Varde) Ochyra, **comb. nov.**
Basionymon: *Grimmia angustissima* P. Varde, Ark. Bot. 3 (8): 148. 9. 1955.

**Schistidium cribrodontium** (Herz.) Ochyra, **comb. nov.**
Basionymon: *Grimmia cribrodontia* Herz., Rep. Spec. Nov. Regn. Veg. 41: 287. 235d–f. 1937.

79. **Racomitrium alare** (Broth.) Par. — Rupicolous in subalpine heath. KIL: Marangu route, near Horombo Hut, 3650–3760 m (314, 315, 322); KEN: Sirimon track, near Liki North Hut, 3600–4200 m (124, 145, 158, 159); ELG: SE slope of the crater rim, 3000 m (79); det. O. Widespread afromontane species known from all the high mountains from Cameroon to Réunion Island at altitude 3000–4500 m. EAB I, IV.

### Funariaceae

80. **Funaria perlaxa** Thér. — *KEN: Sirimon track, on moist soil along a stream, 3600 m (147); det. O. Rare afroalpine species previously known only from Mt. Meru and from Mikeno in Zaire (see Fig. 5).

### Bryaceae

81. **Mielichhoferia cratericola** Broth. — KEN: Sirimon track, on ground in subalpine heath, 3300 m (99, 105); det. O. Afroalpine species known only from Mt. Kenya, Kilimanjaro Mts., Mgahinga and Ninagongo volcanoes. EAB IV.
82. **Brachymenium leptophyllum** (C. Muell.) Jaeg. — Corticolous. K: Eldoret, 2100 m (22, 24); on *Acacia* sp. by road Nairobi—Kitale 55 km before Eldoret, c. 2000 m (20); KEN: near Sirimon Gate, 2550 m (192); UGA: Gulu (435); CAR: Zemio (439); Bangui (453); det. O. A very widespread species in the whole tropical Africa. EAB III.
83. **Bryum alpinum** Huds. ex With. — ELG: SE slope of the crater rim, on ground, 3400 m; coll. SZ; KEN: Sirimon track, below Liki North Hut, on moist rocks, 3900 m (128); det. O. Cosmopolitan species, montane in tropical Africa occurring from Cameroon to South Africa. EAB III, IV.
84. **Bryum andicola** Hook. — Corticolous and terricolous. MER: W slope of the crater rim, 2700 m (356, 368); det. O. According to HAJI MOHAMED (1979) this is a widespread species from Central African Republic to South Africa. Moreover, it is widespread in tropical America and on Hawaiian Islands.
85. **Bryum arachnoideum** C. Muell. — Corticolous and terricolous. T: Serengeti National Park, Naabi Hills, 1600 m (217a); *UGA: Kampala (420); det. O. Presumably widespread in East Africa and on East African Islands but sterile plants are not distinguished from *Bryum argenteum* var. *lanatum*.
86. **Bryum argenteum** Hedw. — K: between Nakuru and Naivasha, Kariandusi, on soil (84); T: Arusha, on a wall of building (211); Ngorongoro Crater, tourist office, on a wall of building on parking (239); UGA: Kampala, on a pavement in Polish Embassy. (416); det. O. Cosmopolite species widespread in tropical Africa. EAB I, II (as var. *lanatum*), III, IV.
87. **Bryum capillare** Hedw. — T: Serengeti National Park, Naabi Hills, in grassland, c. 1600 m (231); det. O. Cosmopolite species not rare in tropical Africa. EAB I.
88. **Bryum coronatum** Schwaegr. — Terricolous. K: Likoni near Mombassa, on boulders covered with soil (2, 3, 5); RCA: Bangui, corticolous (455); det. P. and O. Widespread pantropical species common in tropical Africa. EAB I, III.
89. **Bryum huillense** Welw. et Duby — KEN: near Sirimon Gate, on fallen stem, 2550 m (195); MER: on ground in montane rain forest on W slope of the crater rim, 2750 m; coll. SZ; det. O. Widespread palaeotropical species. EAB I, III, IV.
90. **Bryum keniae** C. Muell. — KEN: near Sirimon Gate, on ground in light scrub, 2600 m; coll. SZ, det. O. Widespread afromontane species. EAB I, III, IV.
91. **Bryum pseudotriquetrum** (Hedw.) Gaertn., Meyer et Scherb. — ELG: SE slope of the crater rim, along a small stream, 4300 m (55); det. O. Cosmopolitan species. EAB I, III, IV.

### Rhizogoniaceae

92. **Rhizogonium spiniforme** (Hedw.) Bruch — KIL: Marangu route, between Marangu Gate and Mandara Hut, epiphytic in montane forest, 1940 m; coll. JK, det. O. Widespread pantropical species. EAB I, IV, V.

### Bartramiaceae

93. **Philonotis hastata** (Duby) Wijk et Marg. — UGA: Entebbe near Kampala, on wet soil (426); det. O. Widespread pantropical species. EAB I, IV, V.
94. **Philonotis tomentella** Mol. in Lor. — *ELG: SE slope, on banks along a small stream below the summit, 4300 m (56); *KEN: Sirimon track, subalpine moorland, 3300 m (91); KIL: below Mandara Hut, on ground in shady ravine, 2500 m; coll. SZ; near Horombo Hut, subalpine moorland, 3760–4000 m (312, 332); det. O. Widespread in the Northern Hemisphere with tropical montane disjunction in Asia and Africa. In tropical Africa altimontane, previously known only from Ruwenzori and Kilimanjaro at altitude 3400–3800 m. EAB I, IV, V.
95. **Bartramia ruwenzorensis** Broth. — KEN: Sirimon track, on soil, 3300 m (102); KIL: Marangu route, near Horombo Hut, on rocks, 3760 m (311); det. O. Afroalpine species widespread in East African mountains at altitude 3300–4200 m. EAB IV.
96. **Breutelia diffracta** Mitt. — MER: on ground in subalpine heath on W slope, 2700–2800 m (361, SZ); KIL: Marangu route, below Mandara Hut, on ground, 2500–2700 m (301, SZ); near Horombo Hut, on ground in subalpine heath, 3650 m (327); det. O. Widespread afromontane species occurring from Cameroon to South Africa. EAB I, IV.
97. **Breutelia humbertii** P. Varde et Thér. — *ELG: SE slope of the crater rim, on rocks, 4000 m (69a); *KIL: Marangu route, near Horombo Hut, 3700–3760 m, on rocks (315a, 333); det. DS. Rare afroalpine species previously known only from Muhavura and from Mt. Meru. EAB V.
98. **Breutelia stricticaulis** Dix. — ELG: SE slope of the crater rim, on rocky ground, 4000 m (66a, 69); det. DS. Rare afroalpine species. EAB V.
99. **Anacolia laevisphaera** (Tayl.) Flow. — ELG: SE slope of the crater rim, on rocks, 4000 m (61); MER: W slope of the crater rim, on ground, 2700 m (352, 367); det. DS. Widespread pantropical montane species. EAB IV.

### Erpodiaceae

100. **Erpodium coronatum** (Hook. f. et Wils.) Mitt. — RCA: Bangui, on bark of palm (451); det. O. Submontane and montane species widespread in tropical America from Mexico to Argentina and in West and Central Africa.

### Orthotrichaceae

101. **Amphidium tortuosum** (Hornsch.) Robins. Syn.: *Amphidium cyathicarpum* (Mont.) Broth. fide Robinson 1976: 20. — KIL: Marangu route, near Horombo Hut, on rocks, 3700–4000 m (316, 325); det. DS. Widespread pantropical montane species known also from warm temperate zone of the Southern Hemisphere. EAB IV (as *A. cythicarpum*).
102. **Orthotrichum affine** Brid. — K: Nairobi, Uhuru Highway, corticolous, c. 1800 m (11); det. O. Widespread circumboreal species in tropical Africa widely distributed from Ethiopia to northern Tanzania. EAB IV.
103. **Orthotrichum firmum** Vent. — Corticolous. ELG: SE slope of the crater rim, 2200 m (30); K: Eldoret, c. 2100 m (25a); on *Acacia* sp. by the road Nairobi—Kitale, 55 km before Eldoret, c. 2100 m (18); TAN: Serengeti National Park, Naabi Hills, 1600 m (222); det. O and DS. Widespread afromontane species occurring in East Africa from Ethiopia to northern Tanzania. Recently Lewinsky (1980) reported this species from the Nilghiri Hills in South India.

104. **Orthotrichum rupestre** Schwaegr. — Rupicolous in alpine zone. ELG: SE slope of the crater rim, 4000 m (71); KEN: Sirimon track, near Liki North Hut, 3800–4000 m (108, 117, 120, 133 and SZ); det. O and DS. Widespread in boreal and temperate parts of the Northern Hemisphere with bipolar disjunction in New Zealand, Australia and on Kerguelen Islands, altimontane in East Africa.

105. **Groutiella laxotorquata** (Besch.) Wijk et Marg. — CAR: Bangui, on bark of palm (454); det. O. Tropical African lowland species known from Cameroon to East African Islands. EAB I, IV.

106. **Macrocoma tenue** (Hook. et Grev.) Vitt — Epiphytic. K: Nairobi, Uhuru Highway, 1800 m (27); Eldoret, 2100 m (27); ELG: SE slope of the crater rim, 2200 m (32); T: Serengeti National Park, Naabi Hills, 1600 m (223); det. O. According to VITT (1980a) it is widespread species in East Africa from Ethiopia to northern South Africa. In tropical Africa occurs only the typical variety of this species, while in tropical America from Mexico to Argentina grows var. *sullivantii* (VITT 1980b).

107. **Macrocoma abyssinica** (C. Müll.) Vitt — K: Eldoret, *Acacia* grove, ramicolous, 2450 m (21b); ELG: S 2200 m, corticolous (35b); det. P. East African montane species known from Ethiopia to Malawi.

### Racopilaceae

108. **Racopilum africanum** Mitt. — UGA: Entebbe, on soil and at tree base (428, 430, 431); det. O. Widespread in tropical Africa from Guinea to East African Islands. EAB I, IV, V.

109. **Racopilum buettneri** Broth. — RCA: Zemio, on bark of palm (440); det. O. Uncommon West African species occurring from Togo to Central Africa.

110. **Racopilum capense** Broth. — KIL: Marangu route, near Horombo Hut, 3760 m, on ground (269); T: Ngorongoro Crater rim, epiphytic in bamboo thickets, 2500 m (264); det. O. Widespread in tropical and in South Africa. EAB IV.

### Hedwigiaceae

111. **Braunia arbuscula** Welw. et Duby — MER: W slope of the crater rim, epiphytic, 2700 m (345); det. O. Widespread afromontane species. EAB I.

112. **Braunia secunda** (Hook.) B.S.G. — K: Eldoret, epiphytic, 2100 m (23, 26, 49); 55 km before Eldoret by the road Nairobi—Kitale, on *Acacia*, c. 2000 m (19); det. O. Pantropical montane species in Africa widespread from Kenya to Cape. EAB I.

113. **Hedwigidium integrifolium** (P. Beauv.) Dix. — KEN: Sirimon track, on dry rocks, 3300–3400 m (94, 95, 104); near Liki North Hut, on dry rocks, 3900 m (141); det. O. Cosmopolitan oceanic species, widespread in tropical Africa. EAB IV, V.

114. **Hedwigia ciliata** (Hedw.) P. Beauv. — *KEN: Sirimon track, on rocks in dry situation, 2800–3300 m (98a, SZ); KIL: Marangu route, near Horombo Hut, 3700 m, on dry rocks (322a); det. O. Cosmopolitan species, altimontane in East Africa known previously from Kilimanjaro, Mt. Elgon, Ruwenzori, Muhavura, Malawi and Madagascar. EAB I, IV.

### Cryphaeaceae

115. **Schoenobryum robustum** (Broth.) Manuel. Syn.: *Acrocryphaea robusta* Broth. — K: Ngong Hills near Nairobi, Ngong town, epiphytic, 2400 m (205); T: Serengeti National Park, Naabi Hills, epiphytic, 1600 m (219, 226); det. O. Widespread Central and East African submontane and montane species. EAB I, IV, V.

116. **Cryphaea protensa** Bruch et Schimp. ex C. Muell. — K: Ngong Hills near Nairobi, Ngong town, epiphytic, 2400 m (198); det. O. Widespread submontane and montane species.
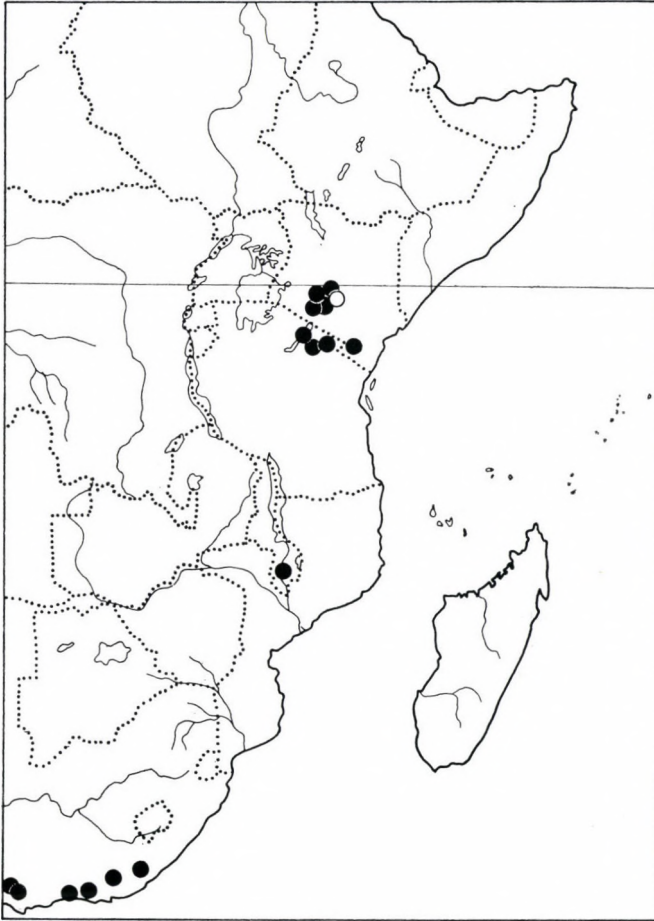
*Fig. 6.* Distribution of *Forsstroemia producta*, a widespread xerophytic element in East and South African mountains

117. **Forsstroemia producta** (Hornsch.) Par. — Epiphytic. K: Nyeri (89); det. O. *Ol Doinyo Sapuk National Park near Thika, 2250 m (396); det. DS. Widespread in tropical Africa occurring from Kenya to Cape in South Africa. EAB IV, V (see Fig. 6).

**Leucodontaceae**

118. **Leucodon dracaenae** Vent. — Epiphytic. K: Eldoret, 2100 m (25); Kitale, 1800 m (48); between Eldoret and Kitale, c. 1900 m (51); ELG: SE slope of the crater rim, 2750 m (73); KEN: near Sirimon Gate, 2600 m (182); T: Ngorongoro Crater rim, 2500 m (235, 247, 254); Serengeti National Park, Naabi Hills, 1600 m (212, 228); det. DS and O. Widespread afromontane species ranging from Ethiopia to southern Tanzania. EAB I, IV, V.
119. **Leucodon laxifolius** C. Muell. et Fleisch. — *ELG: SE slope, epiphytic in montane rain forest, 2370–3000 m (43, 78); MER: W slope of the crater rim, epiphytic 2700 m (384); det. O. Uncommon afromontane species occurring from Ethiopia to northern Tanzania. EAB I, V.

120. **Antitrichia curtipendula** (Hedw.) Brid. — Epiphytic. ELG: SE slope of the crater rim, 3700–4000 m (53, 59); KEN: Sirimon track, below Liki North Hut, 3800 m (134); MER: W slope of the crater rim, 2650–2700 m (357, 371); det. O. Northern temperate species, in tropical Africa altimontane occurring at altitude 2500–4300 m. EAB I, IV, V.
121. **Pterogonium gracile** (Hedw.) Sm. — Epiphytic. K: Nairobi, Uhuru Highway, 1800 m (12); KEN: near Sirimon Gate, 2600 m (185); MER: W slope of the crater rim, 2700 m (360, 364); KIL: Marangu route, near Mandara Hut, 2730 m (292); T: Ngorongoro Crater rim, 2500 m (258); det. O. Widespread in mediterranean region in W Europe and in California, in tropical Africa widely distributed from Kenya to Cape and Madagascar. EAB I, IV, V.

**Trachypodaceae**

122. **Trachypodopsis serrulata** (P. Beauv.) Fleisch. var. **serrulata** Epiphytic. K: Ol Doinyo Sapuk National Park near Thika, 2150 m (379a, 384a); T: Serengeti National Park, Naabi Hills, 1600 m (362); Ngorongoro Crater rim, 2500 m (249); MER: W slope of the crater rim, 2700–2800 m (356b, 363, 386); det. O. Palaeotropical species widespread in tropical Africa. EAB I, IV.

**Pterobryaceae**

123. **Calyptothecium hoehnelii** (C. Muell.) Argent — Epiphytic. K: Ngong Hills near Nairobi, Ngong town (209); KIL: Marangu route, between Marangu Gate and Mandara Hut, 1700–2500 m (267a, 274); det. O. Submontane species widespread in East and in South Africa. EAB I, II, IV, V.
124. **Calyptothecium planifrons** (Ren. et Card.) Argent — Z: NW Prov., Zambezi Rapids 2.5 km above Zambezi bridge on the Mwinilunga — Angola Road, corticolous, 1300 m (K 0027c); det. P. Uncommon tropical African species. EAB V.

**Meteoriaceae**

125. **Aerobryidium subpiligerum** (Hampe) Card. — Epiphytic. K: *Ol Doinyo Sapuk National Park, 2250 m (405); MER: W slope of the crater rim, 2700 m (355); det. O. Lemurian species occurring mostly in the old crystalline massifs in East Africa. EAB I, II, V.
126. **Papillaria africana** (C. Muell.) Jaeg. — Epiphytic. K: *Ol Doinyo Sapuk National Park near Thika, 2250 m (410); Nyeri (85); Ngong Hills near Nairobi, 2400 m (SZ); KEN: Sirimon Gate, 2550–2600 m (150, 170, 171, 181); KIL: Marangu route, near Mandara Hut, 2730 m (306); MER: W slope of the crater rim, 2600–2700 m (342, 370, 377, 381); T: Ngorongoro Crater rim, 2500 m (263); det. O; Serengeti National Park, Naabi Hills, 1600 m (227). Widespread in tropical Africa from Ethiopia to South Africa and East African Islands. EAB I, II, IV, V.
127. **Pilotrichella ampullacea** (C. Muell.) Jaeg. — Epiphytic. K: Ngong Hills near Nairobi, Ngong town, 2400 m (201); *Ol Doinyo Sapuk National Park near Thika, 2150 m (404, 409); KEN: near Sirimon Gate, 2550 m (152); MER: W slope of the crater rim, 2600 m (369); T: Ngorongoro Crater rim, 2400 m (243); det. O. Submontane and montane species widespread in Central and in East Africa and on East African Islands. EAB I, II, IV, V.
128. **Pilotrichella cuspidata** Broth. — Epiphytic. K: Ngong Hills near Nairobi, Ngong town, 2400 m (203, 206, 207, and SZ); *Ol Doinyo Sapuk National Park near Thika, 2150 m (394, 402, 411); MER: W slope of the crater rim, 2700–2750 m (353, 378, 380); T: Ngorongoro Crater rim, 2500 m (246, 253, 261); det. O. Submontane and montane species widespread in East Africa. EAB I, IV, V.

129. **Pilotrichella pentasticha** (Brid.) Wijk et Marg. — Epiphytic. K: Nyeri (87); ELG: SE slope of the crater rim, montane forest, 2200 m (31); det. P and O. Uncommon species in tropical continental Africa and on East African Islands, and in Central America.
130. **Pilotrichella** cf. **stuhlmannii** Broth. — K: Ol Doinyo Sapuk National Park, epiphytic, 2200 m (408, 415); det. O. Rare and little known species occurring in East Africa.

## Neckeraceae

131. **Leptodon smithii** (Hedw.) Web. et Mohr var. **smithii** — Epiphytic in relatively dry type of montane forests. K: *Ol Doinyo Sapuk National Park near Thika, 2200 m (392); ELG: SE slope of the crater rim, 2200 m (29); KEN: near Sirimon Gate, 2550–2650 m (174, 179, 188); T: Serengeti National Park, Naabi Hills, 1600 m (216); det. O. Widespread in tropical East Africa from Ethiopia to northern Tanzania. Moreover, it is common in mediterranean region of Europe and N Africa and in W Europe, rare in N America. Widespread in warm temperate zone of the Southern Hemisphere (New Zealand, Australia, South Africa and Patagonia). EAB IV.

 — var. **beccarii** (C. Muell.) Tong. — KEN: near Sirimon Gate, epiphytic, 2600 m (170a); K: *Ol Doinyo Sapuk National Park near Thika, epiphytic in bamboo thickets, 2200 m (393); Ngorongoro Crater rim, epiphyte, 2500 m (233c); det. O. This variety is widespread in East African mountains from Ethiopia to northern Tanzania growing together with typical variety in drier forests as epiphyte. EAB I, IV.
132. **Neckera platyantha** (C. Muell.) Par. — Epiphytic in submontane and montane forests. ELG: SE slope of the crater rim, 3000 m (58); KEN: Sirimon track, 2600 m (180); T: Ngorongoro Crater rim, c. 2500 m (248); det. O. Widespread afromontane species occurring from Ethiopia to Tanzania. EAB I, IV.
133. **Neckera remota** Bruch et Schimp. in C. Muell. — Epiphytic in montane and submontane forests. ELG: SE slope of the crater rim, 2200–2700 m (52, 80); KEN: Sirimon Gate, 2550 m (191); K: Ngong Hills near Nairobi, Ngong town, 2400 m (204); T: Ngorongoro Crater rim, 2500 m (242, 268); det. DS and O. Widespread afromontane species. EAB I, IV.
134. **Neckera submacrocarpa** Dix. — KEN: Sirimon track, epiphytic in montane rain forest, 2600 m (175); det. O. Widespread afromontane species ranging from Cameroon to Tanzania. EAB I, IV.
135. **Porothamnium hildebrandtii** (C. Muell.) Fleisch. — T: S slope of Ngorongoro Crater rim, epiphytic in bamboo thickets, 2500 m (262, 266); det. O. Widespread afromontane species occurring from Cameroon to South Africa and East African Islands. EAB I, II, IV, V.
136. **Porothamnium molliculum** (Broth.) Fleisch. — T: *S slope of Ngorongoro crater rim, epiphytic in bamboo thickets, 2500 m (257); det. O. Uncommon species in tropical Africa occurring from Cameroon to Tanzania. EAB IV, V.
137. **Porotrichum ruficaule** C. Muell. — *MER: W slope of the crater rim, epiphytic in montane rain forest, 2700 m (374); KIL: Marangu route, near Mandara Hut, 2700–2750 m (293, 304); epiphytic, near Horombo Hut, 3500 m (319); det. O. Afromontane species previously known only from Nairobi at 1700 m and from Kilimanjaro at altitude 2300 m. EAB I.

## Rigodiaceae

138. **Rigodium kilimandscharicum** (Broth.) Par. — KIL: Marangu route, near Mandara Hut, epiphytic in montane forest, 2730 m (295); near Horombo Hut, epiphytic on giant Senecio, 3500 m (319a); det. O. Southeast African montane species known from Tanzania to Malawi. EAB I, V (see Fig. 7).
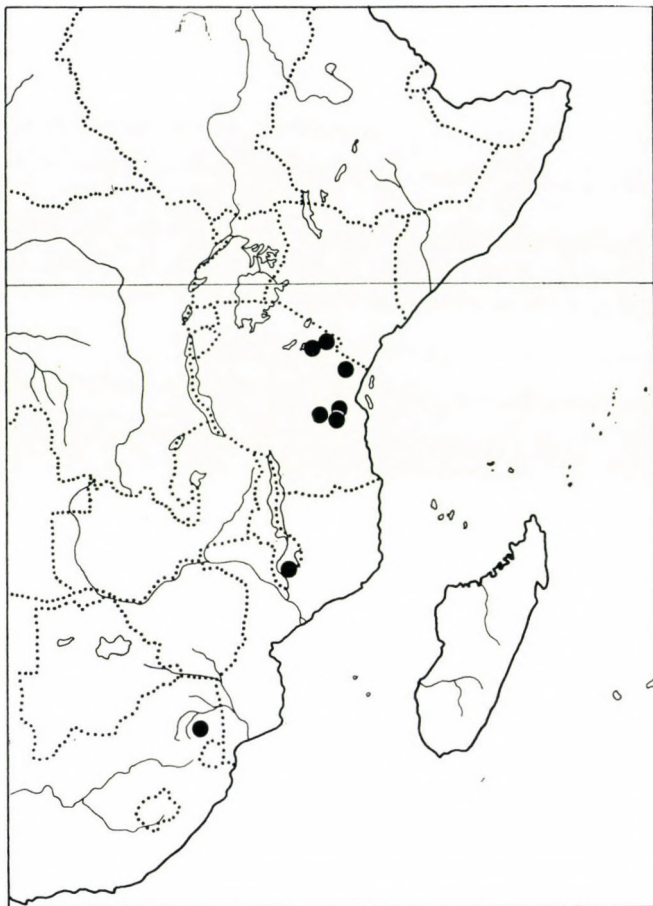
*Fig. 7.* Distribution of *Rigodium kilimandscharicum*, a Southeast African montane element with tropical American affinity

### Hookeriaceae

139. **Schizomitrium africanum** (Mitt.) Ochyra, **comb. nov.**
Basionymon: *Callicostella africana* Mitt., Trans. Linn. Soc. London 23: 53. 5f. 9. 1860.
UGA: Entebbe near Kampala, on soil together with Vesicularia galericulata (429); det. O. Widespread in tropical Africa from Cameroon to East African Islands. EAB I.

The genus *Schizomitrium* is very widespread in tropical Africa and several species were recognized under the name *Callicostella* (DEMARET and P. de la VARDE 1952; DEMARET 1965). However, CROSBY (1975) has shown that *Callicostella* (C. Muell.) Mitt. 1859 is nomenclaturally superfluous name for *Schizomitrium* B.S.G. 1851. Since all African taxa exclud-

ing only *Schizomitrium papillatum* var. *brevifolium* have not previously been given names in *Schizomitrium*, the appropriate combinations are made below:

**Schizomitrium** sect. **Convergentes** (Demar. et P. Varde ex Demar.) Ochyra, **comb. nov.**
Basionymon: *Callicostella* sect. *Convergentes* Demar. et P. Varde ex Demar., Bull. Jard. Bot. Bruxelles 35: 92. 1965.

**Schizomitrium** sect. **Rectae** (Demar. et P. Varde ex Demar.) Ochyra, **comb. nov.**
Basionymon: *Callicostella* sect. *Rectae* Demar. et P. Varde ex Demar., Bull. Jard. Bot. Bruxelles 35: 92. 1965.

**Schizomitrium** sect. **Divergentes** (Demar. et P. Varde ex Demar.) Ochyra, **comb. nov.**
Basionymon: *Callicostella* sect. *Divergentes* Demar. et P. Varde ex Demar., Bull. Jard. Bot. Bruxelles 35: 92. 1965.

**Schizomitrium applanatum** (Broth. et Bryhn) Ochyra, **comb. nov.**
Basionymon: *Callicostella applanata* Broth. et Bryhn, Vorh. Vid. Selsk. Christiania 1911 (4): 19. 1911.

**Schizomitrium ascensionis** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria ascensionis* C. Muell., Bot. Jahrb. 5: 84. 1883.

**Schizomitrium attenuatum** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria attenuata* C. Muell., Bot. Jahrb. 5: 88. 1883.

**Schizomitrium brevipes** (Broth.) Ochyra, **comb. nov.**
Basionymon: *Hookeria brevipes* Broth., Bot. Jahrb. 24: 258. 1897.

**Schizomitrium chevalieri** (Broth. in Corb.) Ochyra, **comb. nov.**
Basionymon: *Callicostella chevalieri* Broth. in Corb., Bull. Mus. Hist. Nat. Paris 18 (2): 113. 1912.

**Schizomitrium chionophyllum** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria chionophylla* C. Muell., Flora 69: 282. 1886.

**Schizomitrium constrictum** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria constricta* C. Muell., Flora 69: 515. 1886.

**Schizomitrium emarginatulum** (Broth. in Corb.) Ochyra, **comb. nov.**
Basionymon: *Callicostella emarginatula* Broth. in Corb., Bull. Mus. Hist. Nat. Paris 18 (2): 114. 1912.

**Schizomitrium eroso-truncatum** (Card.) Ochyra, **comb. nov.**
Basionymon: *Callicostella eroso-truncata* Card., Rev. Bryol. 36: 49. 1909.

**Schizomitrium fissidentellum** (Besch.) Ochyra, **comb. nov.**
Basionymon: *Hookeria fissidentella* Besch., Ann. Sci. Nat. Bot. ser. 6, 10: 284. 1880.

**Schizomitrium gabonense** (Broth. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella gabonensis* Broth. et P. Varde, Bull. Soc. Bot. France 72: 361. 13C. 1925.

**Schizomitrium lacerans** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria lacerans* C. Muell., Linnaea 40: 250. 1876.

**Schizomitrium laeviusculum** (Mitt.) Ochyra, **comb. nov.**
Basionymon: *Callicostella laeviuscula* Mitt., Phil. Trans. R. Soc. London 168: 392. 37B. 1879.

**Schizomitrium leptocladulum** (C. Muell. ex Broth.) Ochyra, **comb. nov.**
Basionymon: *Hookeria leptocladula* C. Muell. ex Broth., Bot. Jahrb. 24: 258. 1897.

**Schizomitrium maclaudii** (Par. et Broth.) Ochyra, **comb. nov.**
Basionymon: *Hookeria maclaudii* Par. et Broth., Rev. Bryol. 30: 103. 1903.

**Schizomitrium papillosulum** (Broth. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella papillosula* Broth. et P. Varde, Bull. Soc. Bot. France 72: 363. 14C. 1925.

**Schizomitrium parvocellulatum** (Demar. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella parvocellulata* Demar. et P. Varde, Bull. Jard. Bot. Bruxelles 22: 342. 38. 1952.

**Schizomitrium perpapillatum** (Broth. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella perpapillata* Broth. et P. Varde, Bull. Soc. Bot. France 72: 361. 14B. 1925.

**Schizomitrium perrotii** (Par.) Ochyra, **comb. nov.**
Basionymon: *Hookeria perrotii* Par., Ind. Bryol. Suppl. 187. 1900.

**Schizomitrium pusillum** (Broth. ex Demar. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella pusilla* Broth. ex Demar. et P. Varde, Bull. Jard. Bot. Bruxelles 22: 343. 39. 1952.

**Schizomitrium salaziae** (Besch.) Ochyra, **comb. nov.**
Basionymon: *Hookeria salaziae* Besch., Ann. Sci. Nat. Bot. ser. 6, 10: 284. 1880.

**Schizomitrium seychellense** (Besch.) Ochyra, **comb. nov.**
Basionymon: *Hookeria seychellensis* Besch., Ann. Sci. Nat. Bot. ser. 6, 10: 285. 1880.

**Schizomitrium subemarginatulum** (Broth. et P. Varde) Ochyra, **comb. nov.**
Basionymon: *Callicostella subemarginatula* Broth. et P. Varde, Bull. Soc. Bot. France 72: 360. 13B. 1925.

**Schizomitrium triste** (C. Muell.) Ochyra, **comb. nov.**
Basionymon: *Hookeria tristis* C. Muell., Hedwigia 38: 130. 1899.

**Schizomitrium usambaricum** (Broth.) Ochyra, **comb. nov.**
Basionymon: *Hookeria usambarica* Broth., Bot. Jahrb. 20: 202. 1894. Annotation by O.

### Fabroniaceae

140. **Rhizofabronia perpilosa** (Broth.) Par. — KIL: Marangu route, near Horombo Hut, on rotten wood, 3700 m (323); det. DS. Afromontane species occurring from Cameroon to northern Tanzania. Distribution map of this species was provided by Bizot et al. (1979). EAB I, IV, V.
141. **Fabronia pilifera** Hornsch. — Corticolous. K: Nairobi, Uhuru Highway, 1800 m (13a, 45); Polish Embassy (196); UGA: Gulu (434); CAR: Zemio (438); det. O. Widespread in tropical Africa from Sahara to South Africa and East African Islands. It is presumably conspecific with other African species. EAB I, V.

### Leskeaceae

142. **Lindbergia patentifolia** Dix. — T: Serengeti National Park, Naabi Hills, 1600 m, corticolous (217); det. O. Uncommon submontane species occurring in East Africa from Uganda and Kenya to Zimbabwe.

### Thuidiaceae

143. **Hylocomiopsis cylindricarpa** Thér. — KEN: near Sirimon Gate, on tree stem, 2550 m (183); MER: W slope of the crater rim, on ground, 2800 m (SZ); det. O. Widespread afromontane species known from Cameroon and Ethiopia to southern Tanzania. EAB V, incl. distribution map.
144. **Rauiella subfilamentosa** (Besch.) Wijk et Marg. — K: Nyeri, on tree branches (90); det. O. Uncommon in East Africa from Kenya to Cape and Madagascar.
145. **Thuidium chenagonii** C. Muell. ex Ren. et Card. — K: *Ol Doinyo Sapuk National Park, on ground in grassland, 2200 m (386a); MER: W slope of the crater rim, on ground in montane forest, 2750 m (385); det. O. Widespread in tropical Africa from Guinea to Zimbabwe and Moçambique and East African Islands. Submontane and montane species occurring at altitude 600–2200 m. EAB IV.
146. **Thuidium involvens** (Hedw.) Mitt. subsp. **thomeanum** (Broth.) Touw — RCA: Bangassou, on bark of palm (448); det. O. West African lowland species known from Ivory Coast to northern Zaire. Distribution map was provided by Touw (1976).
147. **Thuidium matarumense** Besch. — MER: W slope of the crater rim, in shady, relatively moist situation in ravine, 2600–2800 m (339 and SZ); KIL: Marangu route, near Mandara Hut, at tree base, 2730 m (305); det. O. Widespread afromontane species growing at altitude 900–3500 m in Uganda, Kenya, Tanzania, South Africa and on East African Islands. This species was mapped by Touw (1976).

### Amblystegiaceae

148. **Amblystegium serpens** (Hedw.) B.S.G. — UGA: Kampala, on bark in town centre (421); Entebbe near Kampala, on tree stem together with *Fabronia pilifera* (431a); det. DS and O. Widespread boreal and temperate species of the Northern Hemisphere. New for tropical Africa.
149. **Drepanocladus uncinatus** (Hedw.) Warnst. — MER: W slope of the crater rim, on ground, 2800 m (SZ); KIL: Marangu route, above Mandara Hut, subalpine moorland, 2700–2750 m (297 and SZ); det. O. Cosmopolitan species, in tropical Africa altimontane known from Ruwenzori, Mt. Kenya, Mt. Elgon, Mt. Meru and Kilimanjaro. EAB I, IV, V.

### Brachytheciaceae

150. **Homalothecium afro-striatum** (C. Muell.) Ochyra, **stat. et comb. nov.**
Basionymon: *Palamocladium sericeum* var. *afro-striatum* C. Muell., Hedwigia 38: 135. 1899.
Syn.: *Palamocladium sericeum* (Jaeg.) C. Muell.
K: Nyeri, on tree stem (88); KEN: Sirimon track, epiphytic, 2500–2700 m (166, 176 and SZ); near Liki North Hut, on ground, 3800 m (122); KIL: Marangu route, above Mandara Hut, epiphyte, 2730 m (304a); MER: W slope of the crater rim, epiphytic in montane rain forest, 2700–2800 m (350, 365, 376, 379, 388); T: S slope of Ngorongoro Crater rim, epiphytic in bamboo thickets, 2400 m (255); det. DS and O. Widespread afromontane species known from East and South Africa. EAB I, IV, V.
ROBINSON (1962) in his generic revision of the North American Brachytheciaceae came to the conclusion that the characters differing the genera *Homalothecium* and *Palamocladium* are not sufficient at the generic level and included *Palamocladium* as a subgenus in *Homalothecium*. Following this concept the African plants should be renamed. However, the epithet "sericeum" has already been used in *Homalothecium* for well-known Holarctic species. The oldest validly published name for this taxon seems to be epithet "*afrostriatum*" which was used by MUELLER (1899) at varietal rank for plants collected in South Africa. On the other hand, the interrelationships between Asian *Homalothecium nilghiriense* and American *H. leskeoides*, and *H. afro-striatum* need further examination and it is possible that they are conspecific. Annotation by O.

151. **Brachythecium afroglareosum** (Broth.) Par. — T: *S slope of the Ngorongoro Crater rim, terricolous and corticolous in bamboo thickets, 2500 m (250, 265, 267); det. O. Uncommon East African species known from Ethiopia, Uganda, Kenya and Tanzania. EAB I, IV, V.
152. **Brachythecium borgenii** (Hpe) Jaeg. Syn.: *Brachythecium atrotheca* (Duby) Besch. — *MER: W slope of the crater rim, on ground, 2700 m (SZ); KIL: Marangu Route, near Mandara Hut, on ground, 2700 m (SZ); det. O. Lemurian montane species known from Ethiopia and Tanzania to Mauritius. EAB I, IV, V (see Fig. 8).
153. **Brachythecium implicatum** (Hornsch.) Jaeg. — *ELG: SE slope of the crater rim, terricolous, 4000 m (62a); det. O. Rare afromontane species known from East African volcanic area. EAB I.
154. **Brachythecium spectabile** Broth. — KIL: Marangu route, above Horombo Hut, on stony ground in shady ravine, 3500 m (SZ); det. O. Uncommon afroalpine species known from Ruwenzori, Mt. Kenya, Muhavura, Karishimbi and Kilimanjaro. EAB I.
155. **Brachythecium vellereum** (Mitt.) Jaeg. — K: Nairobi, Uhuru Highway, epiphytic, 1800 m (10); T: Serengeti National Park, Naabi Hills, on wall of building on parking, 1600 m (232); det. O. Widespread afromontane–afroalpine species. EAB IV, V.
156. **Schimperella atrotheca** P. Varde — T: *Serengeti National Park, Naabi Hills, 1600 m, epiphytic (221); det. O. Afromontane species occurring from Ethiopia to Tanzania. EAB IV, V.
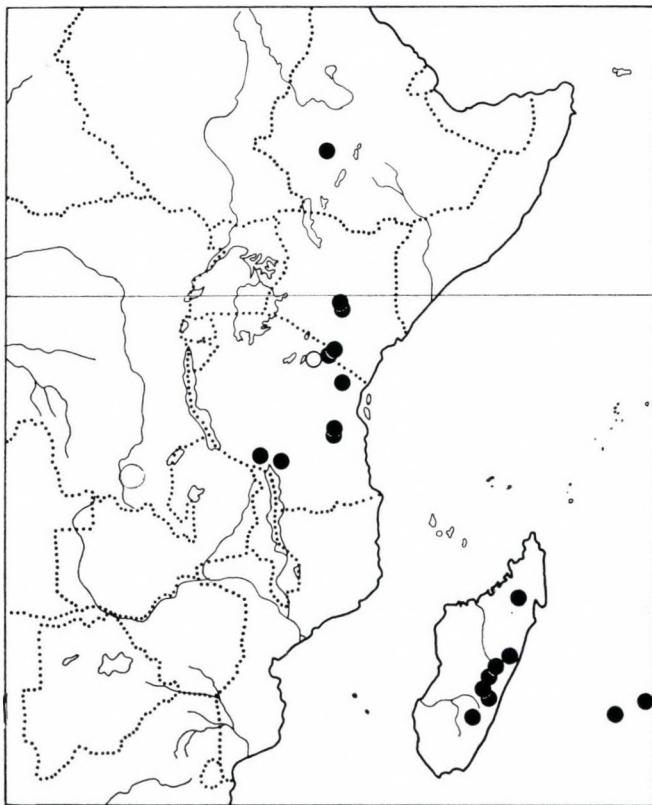
*Fig. 8* .Distribution of ***Brachythecium borgenii***, a typical East African — Lemurian montane species

157. **Eurhynchiella decurrens** P. Varde — ELG: SE slope of the crater rim, on ground, 4000 m (66); *MER: W slope of the crater rim, on ground in montane rain forest, 2700 m (359); det. O. Uncommon afroalpine species previously known from Ruwenzori, Muhavura, Mt. Kenya, Kilimanjaro and Nguru Mts., see the distribution map in Bizot et al. (1978). EAB IV, V.

158. **Kindbergia africana** (Herz.) Ochyra, **comb. nov.**

Basionymon: *Eurhynchium africanum* Herz., Rep. Spec. Nov. Regn. Veg. 41: 288. 235i–l. 1937.

ELG: SE slope of the crater rim, epiphytic in montane forest, 2730 m (76); det. O. Rare afromontane species known only from Ruwenzori and Mt. Elgon.

*Eurhynchium africanum* Herz. is characterized by its remarkable heterophylly. Therefore, with no doubt it belongs to the genus *Stokesiella* (Kindb.) Robins. which was split out from *Eurhynchium* by Robinson

(1967). However, *Stokesiella* (Kindb.) Robins. is a later and illegitimate homonym of *Stokesiella* Lemmermann. OCHYRA (1982) proposed a new generic name *Kindbergia* to replace it. Apart from the above new combination the following one is made to accommodate another African taxon:

**Kindbergia africana** var. **latifolia** (Demar. et Leroy) Ochyra, **comb. nov.**

Basionymon: *Eurhynchium africanum* Herz. var. *latifolium* Demar. et Leroy, Expl. Parc Nat. Albert, Mission J. Lebrun (1937–1938) 6: 52–53. 55–57. 1944.

Annotation by O.

**Entodonaceae**

159. **Erythrodontium barteri** (Mitt.) Broth. — *SUD: Juba, corticolous (436); det. O. West African species known from Guinea to Zaire and Angola.
160. **Erythrodontium subjulaceum** (C. Muell.) Par. — UGA: Kampala, on tree stem in town centre (418, 425); det. O. Widespread in tropical Africa. EAB I, IV, V.
161. **Entodon dregeanus** (Hornsch.) C. Muell. — T: Ngorongoro Crater rim, epiphytic in bamboo thickets, 2500 m (255a); det. O. Widespread East African species occurring from Ethiopia to Zimbabwe. EAB IV, V.
162. **Levierella perserrata** P. Varde et Leroy — K: *Ol Doinyo Sapuk National Park, epiphytic, 2250 m (395); det. DS. Uncommon East African species occurring from Ethiopia to Zambia. EAB IV, V.

**Plagiotheciaceae**

163. **Stereophyllum nitens** Mitt. — RCA: Bangassou, corticolous on palm (442); det. O. Widespread in tropical Africa. EAB IV, V.
164. **Isopterygium phlyctitheca** P. Varde — KIL: Marangu route, between Marangu Gate and Mandara Hut, on stream bank in evergreen mist forest on humid rocky slope, 2300 m, coll. JK 5306, det. O. East African montane species known from Tanzania and Zaire (Mt. Biega). EAB IV.

**Sematophyllaceae**

165. **Wijkia trichocolea** (C. Muell.) Crum — KIL: Marangu route, below Mandara Hut, 2500 m, epiphytic (270, 273a); det. O. Widespread in eastern tropical Africa from Ethiopia to Natal. EAB IV, V.
166. **Sematophyllum subbrachytheciforme** P. Varde — KEN: Sirimon Gate, on decaying wood, 2550 m (194); det. O. East African montane species known from Kenya to Zambia. EAB V.

**Hypnaceae**

167. **Hypnum africanum** (P. Varde) Ochyra, **comb. nov.**

Basionymon: *Breidleria africana* P. Varde, Bull. Soc. Bot. France 87: 362. 2f. 18. 1940.

*MER: W slope of the crater rim, at tree base, 2750 m (389); det. O. Afroalpine species previously known only from Kilimanjaro, Ruwenzori and Muhavura. EAB V.

Following widely accepted concept I include the genus *Breidleria* in synonymy of the genus *Hypnum*. Species previously included in *Breidleria* are treated as a section *Pratensia* B.S.G. within *Hypnum* (Ando 1973). Appropriate new combination was made. Annotation by O.

168. **Hypnum cupressiforme** Hedw. — Epiphytic and terricolous. K: Kitale (8); ELG: SE slope of the crater rim, 2350–2400 m (74, 75, 77); *Ol Doinyo Sapuk National Park near Thika, 2200 m (385a); KEN: Sirimon track, 2600 m (SZ); below Liki North Hut, 3800–3900 m (111, 119, 125, 138, 146); K: Ngong Hills near Nairobi, Ngong town, 2400 m (202); MER: W slope of the crater rim, 2650–2700 m (340, 350a, 354, 358, 365a, 366, 375, 387); KIL: Marangu route, below Mandara Hut, 2500–2700 m (277, 287); det. O. Cosmopolitan species widespread in African mountains. EAB I, IV, V.
169. **Vesicularia galerulata** (Duby) Broth. — UGA: Entebbe near Kampala, on soil (429a); det. O. Widespread in East and South Africa and on South African Islands. EAB I, IV, V.
170. **Mittenothamnium cavifolium** (Dix.) Wijk et Marg. — KEN: near Sirimon Gate, on tree stem, 2550 m (149); KIL: Marangu route, below Mandara Hut, 2500 m (272); det. DS. Widespread in tropical Afrika from Ethiopia to Cape-EAB IV.
171. **Mittenothamnium cygnicollum** (Dix.) Wijk et Marg. — Epiphytic. KIL: Marangu route, below Mandara Hut, 2500–2700 m (271, 283, 307); near Horombo Hut, 3600 m (321); det. O. Widespread afromontane species occurring from Kenya to South Africa. EAB I, IV, V.

### Rhytidiaceae

172. **Rhytidium rugosum** (Hedw.) Kindb. — ELG: SE slope of the crater rim, on ground in alpine zone, 4000 m (60); det. O. Widespread in the Northern Hemisphere, altimontane in East Africa, on Mt. Elgon and Mt. Kenya at altitude 4000–4200 m.

### Hylocomiaceae

173. **Hylocomium splendens** (Hedw.) B.S.G. — ELG: SE slope of the crater rim, on rocks, 4000 m (65); det. O. Widespread in the Northern Hemisphere, altimontane in East Africa occurring on Karisimbi, Ruwenzori, Kilimanjaro, and on Mt. Elgon at altitude 3200–4100 m. Apart from Africa it is known only from New Zealand in the Southern Hemisphere. EAB I.

### Polytrichaceae

174. **Pogonatum oligodus** (C. Muell.) Mitt. — K: Kitale, on soil (7); KEN: Sirimon track, on soil, 3300 m (100); det. P. Uncommon in East and South Africa. EAB IV.
175. **Polytrichum commune** Hedw. — K: Kitale, on soil (6); ELG: SE slope of the crater rim, on soil, 3700–4000 m (54, 72); KEN: Sirimon track, near Liki North Hut, 3900 m (92); KIL: Marangu route, near Mandara Hut, 2730 m, on ground (296); det. O. Cosmopolitan species widespread in tropical Africa. EAB II, IV.
176. **Polytrichum piliferum** Hedw. — KEN: Sirimon track, on soil, 3300 m (101, 107); near Liki North Hut, 3800 m, on soil (115); KIL: Marangu route, near Horombo Hut, 3700 m, on soil (308, 331); det. O. Cosmopolitan species, altimontane in tropical Africa. EAB IV, V.

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# POLLINATION BIOLOGICAL CHARACTERISTICS OF VARIOUS *MALUS* TAXA

M. Soltész,[1] M. Tóth,[2] F. Gyuró,[2] A. Terpó[3] and J. Nyéki[2]

[1] COLLEGE OF THE UNIVERSITY OF HORTICULTURE, KECSKEMÉT, HUNGARY
[2] UNIVERSITY OF HORTICULTURE, DEPARTMENT OF FRUIT GROWING, BUDAPEST, HUNGARY
[3] UNIVERSITY OF HORTICULTURE, BOTANY DEPARTMENT, BUDAPEST, HUNGARY

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The authors began the acclimatization of "*Malus* pollination scheme" to Hungarian conditions in 1977. With respect to one of the most important questions of using *Malus* species as pollinators, on flowering biological and growth characteristics, Nyéki et al. (1980) have published their results. Another important condition for favourable pollination, namely fertilization biological characteristics, was studied in the Soroksár Botanical Garden of the University of Horticulture (SBK), and in the Helvécia Centre of National Agricultural Variety Qualifying Institute, in 1977 and 1978. On the results of two-years' observations, the authors selected the following taxa for further examinations in model orchards. For the 'Jonathan' apple varieties, suitable can be SBK-3 (*M. floribunda*) and SBK-1014 (*M. dasyphylla-pumila*) types. For the 'Starking' variety, SBK-1014 (*M. dasyphylla-pumila*), while for 'Golden Delicious' SBK-1003 (*M. domestica-pumila*) can be recommended.

On the basis of fertilization biological characteristics a few other suitable species (types) were found such as for example SBK-10, SBK-6, SBK-277, SBK-333 but with them it was also found that the flowering taking place at the same time as the Jonathan, Starking and Golden Delicious varieties is below 50%.

In 1978, searching for the possibilities of artificial pollination the authors carried out pollinations with pollen mixtures in the Jonathan and Golden Delicious varieties, some of which provided very noteworthy results. In the case of the Jonathan variety (♀), SBK-336 (*M. pumila*) + Golden Delicious pollen mixture (33% seed formation at harvest time), should be mentioned, while in the Golden Delicious variety (♀), the mixture of SBK-336 + Starking (30.8% seed formation).

Since pollination must be completely ensured in the "*Malus* pollination scheme", for every intensive apple orchard variety two suitable *Malus* pollinators at least should be chosen. To achieve this, the authors are carrying out analyses by drawing further species (types) into their sphere of interest.

## Introduction

The "*Malus* pollination scheme" is expected to have an important role in ensuring the optimal seed formation in intensive apple orchards. Williams (1966) was the first to suggest *Malus* as pollinators in early flowering apple varieties in England (Williams 1975, 1977) and in Holland (Jonkers et al. 1978) carried out a large scale research to find *Malus* pollinators that would match "Cox Orange Pippin", one of the most important West-European apple varieties.

There are several advantages in using *Malus* taxa (s. l. wild apples) as pollinators, compared with the conventional pollinator varieties. In single-variety orchards, variety-specific agrotechniques can be used; by using several *Malus* pollinators jointly in single-variety orchards, fertilization can be more ensured.

In orchards with unfavourable pollination conditions, seed formation can be improved by engrafting upon the varieties; there is a greater density of flowering and pollen producing

in the *Malus* taxa than in the commercial varieties (WILLIAMS 1975, SMITH and KENDALL 1975, JONKERS et al. 1978).

One of the most important advantages of using *Malus* taxa as pollinators — besides their flowering at the same time as the commercial apple varieties — is their fertilization biological suitabilities. In earlier decades, the analyses of fertilization biological characteristics of *Malus* taxa mainly served breeding purposes.

KARAMÜSEVA and BLINOVA (1976) reported on the self-fertilization of the various species as follows:

**Table 1**

| Species | Seed formation, % | Species | Seed formation, % |
|---|---|---|---|
| *M. floribunda* | 100 | *M. sieboldi* | 70–98 |
| *M. sargenti* | 57–80 | *M. kansuensis* | 25–36 |
| *M. zumi* | 32 | *M. coronaria* | 8–25 |
| *M. spectabilis* | 2–15 | *M. sieversii* | 5– 6 |
| *M. florentina* | 0– 6 | *M. prunifolia* | 0– 3.8 |
| *M. cerasifera* | 0– 1.6 | *M. silvestris* | 0– 1.5 |
| *M. baccata* | 0– 1.4 | | |

GRUNER and MEDVEZHOVA (1977) to examine self-fertilization isolated whole trees and placed bees within the isolators. The seed formation of the 15 *Malus* species examined varied between 2.5 and 90.0%.

In the experiments of RUDLOFF and SCHMIDT (1938), *Malus kaido* furnished a result of 51.6% seed formation by self-fertilization.

Several *Malus* species are inclined to apomictic seedling formation (OLDEN 1953), while some of the species are themselves of apomictic origin, as for exemple *M. toringoides*, *M. hupehensis*, *M. sikkiensis* (LUCKWILL and CAMPBELL 1953) of triploids; and *M. rockii* and *M. sargenti* (SAX 1959) of tetraploids.

WILLIAMS (1977) reported on the fertilization of *Malus* species. In the course of ten-year period of observations he found that the pollen of some *Malus* taxa (types) was as effective in the pollination of Cox Orange Pippin apple variety as had been that of the generally used conventional pollinator species (Egremont Russet, Golden Delicious, Worcester, Discovery). He recommends *Malus* cv. Hillier, cv. Golden Hornet, cv. Winter Gold and *M. purpurea* cv. Aldenhamensis types as pollinators for the Cox Orange Pippin variety.

Based on favourable experiences abroad, the *Malus* Pollination Scheme was launched also in Hungary, and so, the clarification of the fertilization biological characteristics of *Malus* taxa came to be a very important task.

Our observations were aimed at determining:

1. What at the seed formation in various *Malus* taxa (types) is like on natural self-fertilization (without artificial pollination, in isolation)?

2. The degree of fertilization capacity in the *Malus* taxa examined, on the basis of the seed formation and seed content of the flowers which pollinated in vivo.

3. The extent of pollen-shooting and sac-producing of *Malus* taxa under in vitro conditions.

4. How the *Malus* taxa affect the seed formation and seed content of Jonathan, Starking and Golden Delicious the three main apple varieties in Hungary?

## Material and methods

Of the *Malus* collection to be found in the Soroksár Botanical Garden (= SBK), of the Horticultural University (at the southern edge of Budapest) the following 17 taxa (types), were chosen for the fertilization biological examinations (code numbers are also given):

SBK-1: *Malus purpurea*
SBK-3: *M. purpurea*
SBK-5: *M. baccata*
SBK-6: *M. spectabilis*
SBK-8: *M. baccata*
SBK-9: *M. purpurea*
SBK-10: *M. halliana*
SBK-277: *M. dasyphylla*
SBK-280: *M. silvestris*
SBK-333: *M. silvestris*
SBK-336: *M. pumila*
SBK-726: *M. silvestris*
SBK-730: *M. silvestris*
SBK-731: *M. silvestris*
SBK-1003: *M. domestica-pumila*
SBK-1014: *M. dasyphylla-pumila*

In 1977 and 1978, observations were made on *Malus* taxa (types) of single root-stocks, on their self-fertilization and on their quality of sexual pollination in a given ecological environment in the neighbourhood of other *Malus* species.

For the observations on self-fertilization 50–200 flowers per tree were isolated at their budding phase; 3–6 pergamen bags were used per species (types) for isolation, and no bees were placed in the isolators. After the flowering of the shoots on the tree had been completed, the pergamen bags were opened, to ensure suitable environmental conditions for the seeds forming in the isolators.

The fertilization of flowers per species (types) that pollinated sexually was estimated on the basis of the seed formation of 150–250 flowers both in the *Malus* taxa (types) and in the control trees of Jonathan and Starking variety marked nearly.

Seed formation was checked after the purification falling (marked by I in the tables), and after fruit falling in June (II in the tables). On the basis of these two values the sexual and the self-fertilization quality in *Malus* taxa could be determined. However, seed formation in itself does not give reliable results on the reproduction biological characteristics, therefore, in 1977, after the June fruit falling the seed content of the fruits and also the number of carpels were counted.

A sufficient quantity of pollen was collected at the beginning of flowering of the marked *Malus* taxa (types) from the Soroksár Botany Garden (SBK), then the pollen physiological as well as reproduction quality examinations were carried out on the main apple varieties in Helvécia, at the Centre of the National Agricultural Variety Qualifying Institute.

Pollen germinating and pollen-sac producing qualities were examined under in vitro conditions, in 10% saccharose solution, at 23 °C, on a deepened petridish object plate in identical pollen concentrations. The rate of sac growth was determined related to the pollen diameter after 24 hours.

Pollination quality was tested on Jonathan, Starking and Golden Delicious varieties. The self-infertility of these three varieties had been proved during earlier examinations (Maliga 1953, 1961; Dániel 1962, Gyuró et al. 1976), therefore the flowers which were to be pollinated had not been castrated. The Jonathan, Starking and Golden Delicious flowers pollinated artificially were isolated in pergamen bags, and their seed formation was registered in three points of time (I and II as in the *Malus* taxa; III: before harvesting).

In the last period, the number of carpels and also the seed content were counted since these indices are also necessary for to assessing the fertilization quality of a given *Malus* taxa (♂). For the examinations related to the fertilization quality, the other two apple varieties (for example, to Golden Delicious the Starking variety and the Jonathan as male variety (♂) and the sexual seed formation were considered as the basis for control. This is justified because in orchards the apple varieties are planted in such a mating pattern.

In the periods of flowering and seed formation there were very great differences between the two years' weather conditions in both areas of observation. In 1977, the weather was warmer than the average, rich in sunshine and dry, while in 1978 it was unusually cool and rainy. This difference strikingly manifest in the time of flowering (a later flowering in 1978) and the extent of seed formation (it was considerably poorer in 1978).

## Results and evaluation

### *Self-fertilization in Malus taxa*

The data on self-fertilization of *Malus* taxa (types) can be seen in Table 2. Of the *Malus* taxa (types) examined, considerable seed formation (23 and 18%) was found in the SBK-5 type. Slight seed formation (6%) was found in the SBK-1003 type, while the rest proved to be self-infertile.

Seed formation in the flowers of sexually pollinated *Malus* taxa:

In 1977, in 4 types, the seed formation of sexually pollinated flowers, near to other *Malus* taxa, was very poor (below 10%); in a further 6 types it was between 10 and 20%. In 1978, after the purification fruit falling (I), seed formation essentially lower than that in the previous year was found in types SBK-1, SBK-9 and SBK-10 ((14.3, 0.5 and 3.5% respectively). In type SBK-8, taken into the examination in 1978, seed formation was also very low (0.5%). In the Jonathan and Starking trees, which were near the *Malus* taxa, an average seed formation of 10–20% was found in the two years of observation.

**Table 2**

*Self-fertilization in various Malus taxa (Budapest-Soroksár 1977–1978)*

| Code No. of the Malus taxa (types) | No. of isolated flower buds | | Seed formation (%) | | | |
|---|---|---|---|---|---|---|
| | | | 1977 | | 1978 | |
| | 1977 | 1978 | I | II | I | II |
| SBK-5 | 118 | 161 | 43.2 | 22.9 | 39.1 | 18.3 |
| SBK-1003 | 48 | — | 43.7 | 6.2 | — | — |
| SBK-10 | 72 | 208 | 4.2 | 2.7 | 0.5 | 0.5 |
| SBK-726 | 63 | — | 3.1 | 1.6 | — | — |
| SBK-1 | 114 | 165 | 1.7 | 0.0 | 1.2 | 0.0 |
| SBK-3 | 86 | 150 | 3.1 | 1.2 | 0.0 | 0.0 |
| SBK-6 | 125 | 104 | 0.0 | 0.0 | 4.8 | — |
| SBK-336 | 100 | 130 | 0.0 | 0.0 | 0.8 | 0.0 |
| SBK-9 | 97 | 185 | 0.0 | 0.0 | 0.5 | 0.0 |
| SBK-7 | 88 | 230 | 0.0 | 0.0 | 0.0 | 0.0 |
| SBK-731 | 54 | 145 | 0.0 | 0.0 | 0.0 | 0.0 |
| SBK-8 | — | 208 | — | — | 0.0 | 0.0 |
| SBK-1014 | 97 | — | 0.0 | 0.0 | — | — |
| SBK-730 | 46 | — | 0.0 | 0.0 | — | — |
| SBK-280 | 80 | — | 0.0 | 0.0 | — | — |
| SBK-333 | 130 | — | 0.0 | 0.0 | — | — |

In intensive apple orchards those *Malus* taxa (types) are more favourable with respect to pollinators whose seed formation is smaller. This however is only an advantage and not an exclusive condition for using them as a pollinator. These data do not give an adequate guide as to what capacity for sexual seed formation the *Malus* taxa have when planted in between the commercial apple varieties (Jonathan, Golden Delicious, Starking).

There is no connection between the seed content and seed formation in the fruits of *Malus* taxa (types). The number of carpels is in general 5 or near to that; exceptions are types SBK-5 with 5.8 and SBK-7 with 4 carpels selected within the *M. baccata* species (Table 3).

## *Germinating and sac growth of the pollen*

The quality of germinating and sac growth of the pollen in *Malus* taxa is shown in Table 4. Of the species examined, types numbered as SBK-336, SBK-731, SBK-280 and SBK-730 had a very good germinating capacity (above 50%). In a further 4 types, it was satisfactory (30–50%), while in the others it was slight and in SBK-7 there was a very weak pollen germinating capacity. The pollen tube was the longest in types SBK-1003 and in the SBK-1014, it was the largest. Fertilizing quality of *Malus* taxa in commercial apple varieties:

The fertilizing quality of the taxa can be assessed on the basis of seed formation and the seed content of the fruits. Both of these indices should be taken into consideration, for a great number of *Malus* taxa (types) have a good fertilization capacity on the basis

**Table 3**

*Rate of fertilization in the naturally pollinated flowers of various Malus taxa (Budapest-Soroksár 1977)*

| Code No. of the Malus taxa (types) | No. of flowers under observation | Seed formation (%) | | Average carpel No. falling to one fruit (piece) | | No. of full seeds falling to one fruit |
|---|---|---|---|---|---|---|
| | | I | II | full | non-full | |
| SBK-6 | 253 | 58.5 | 55.3 | 8.5 | 0.4 | 5 |
| SBK-3 | 216 | 64.8 | 53.2 | 2.2 | 0.6 | 5 |
| SBK-5 | 173 | 81.5 | 41.6 | 4.7 | 1.8 | 5.8 |
| SBK-1003 | 82 | 58.5 | 40.2 | 7.6 | 0.3 | 5 |
| SBK-1 | 278 | 40.2 | 36.3 | 2.4 | 0.2 | 4.8 |
| SBK-1014 | 102 | 26.5 | 25.5 | 5.9 | 1.6 | 5 |
| SBK-9 | 158 | 20.9 | 17.7 | 1.9 | 0.0 | 4.8 |
| SBK-726 | 130 | 42.3 | 16.9 | 7.2 | 0.9 | 5 |
| SBK-730 | 101 | 28.7 | 15.8 | 6.0 | 1.1 | 5 |
| SBK-10 | 114 | 23.6 | 14.9 | 1.7 | 0.2 | 4.9 |
| SBK-277 | 109 | 28.4 | 12.8 | 3.5 | 2.3 | 5 |
| SBK-731 | 115 | 13.9 | 11.3 | 7.7 | 0.5 | 5 |
| SBK-280 | 139 | 17.2 | 3.6 | 7.8 | 0.8 | 5 |
| SBK-333 | 140 | 6.4 | 2.8 | 5.5 | 2.5 | 5 |
| SBK-336 | 129 | 1.5 | 1.5 | 7.0 | 1.0 | 5 |
| SBK-7 | 136 | 9.5 | 0.7 | 3.0 | 1.0 | 4 |

of seed formation, while at the same time the seed content falling to one piece of fruit is low. The reverse of all these also occur in many cases. A seed formation necessary for the achievement of a great number of produce depends on the density rate of flowering. In our three commercial apple varieties (Jonathan, Golden Delicious and Starking) 5–10% seed formation, is considered to be a function of the rate of flowering density, for satisfactory results in fruit growing.

## *Seed formation*

Seed formation results in the Jonathan variety are given in detail in Table 4. The fruit set formed after artificial crossing of the *Malus* species with "Starking" and "Golden Delicious" pollinators or the sexual seed formations near other taxa serve as a basis for comparison. In 1977, 4 *Malus* taxa (types) showed an even higher seed formation than Golden Delicious which is of a better fertilization capacity, while in sexual pollination 7 *Malus* taxa (types) were better. In 1978, seed formation was in general poorer than that in the previous year;

**Table 4**

*S ıc growing of the pollen of various Malus taxa (Helvécia 1977)*

| Code No. of the Malus taxa (types) | No. pollen observed (piece) | Rate of pollens that have brought buds (%) | Length of pollen sacs* |
|---|---|---|---|
| SBK-730 | 226 | 86.3 | 4 |
| SBK-731 | 180 | 79.8 | 2 |
| SBK-280 | 474 | 61.3 | 3 |
| SBK-336 | 999 | 52.2 | 3 |
| SBK-1014 | 391 | 48.8 | 5 |
| SBK-1003 | 604 | 37.9 | 5 |
| SBK-6 | 236 | 34.4 | 2 |
| SBK-277 | 1770 | 29.6 | 3 |
| SBK-726 | 1039 | 24.5 | 2 |
| SBK-333 | 731 | 21.5 | 3 |
| SBK-9 | 943 | 21.5 | 2 |
| SBK-10 | 1047 | 20.2 | 2 |
| SBK-3 | 689 | 18.7 | 3 |
| SBK-1 | 902 | 16.3 | 3 |
| SBK-5 | 799 | 16.3 | 3 |
| SBK-7 | 1067 | 7.0 | 2 |

* Note: The average length of the sacs is:
(1) the same as the diameter of the pollen
(2) 2–4 times that of the pollen diameter
(3) 5–10 times that of the pollen diameter
(4) 11–20 times that of the pollen diameter
(5) greater than 20 times the pollen diameter

**Table 5**

*Effect of pollinator Malus taxa on the seed formation and the seed content in the fruits of Jonathan variety (Helvécia 1977–1978)*

| Code No. of Malus taxa (types) | No. of pollinated flowers | | Seed formation (%) | | | | | | Number of seeds falling to one fruit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1977 | | | 1978 | | | 1977 | | 1978 | |
| | 1977 | 1978 | I | II | III | I | II | III | full | non-full | full | non-full |
| SBK-1003 | 144 | 261 | 66.7 | 41.7 | 34.7 | 69.0 | 8.0 | 6.9 | 5.2 | 0.4 | 6.8 | 2.4 |
| SBK-277 | 196 | — | 42.8 | 35.7 | 29.6 | — | — | — | 3.4 | 0.0 | — | — |
| SBK-726 | 124 | — | 67.7 | 48.4 | 29.0 | — | — | — | 3.8 | 0.5 | — | — |
| SBK-3 | 146 | 234 | 72.6 | 35.6 | 27.4 | 87.2 | 24.3 | 17.5 | 3.7 | 1.7 | 5.8 | 3.5 |
| SBK-1 | 130 | 234 | 75.3 | 30.8 | 21.5 | 88.5 | 16.7 | 14.1 | 2.3 | 1.3 | 5.7 | 0.8 |
| SBK-731 | 105 | 222 | 33.3 | 22.8 | 20.0 | 31.1 | 0.0 | 0.0 | 2.8 | 0.6 | — | — |
| SBK-333 | 190 | — | 63.1 | 26.3 | 20.0 | — | — | — | 3.7 | 1.3 | — | — |
| SBK-6 | 180 | 234 | 50.0 | 23.3 | 18.9 | 73.1 | 26.9 | 17.9 | 4.5 | 0.0 | 5.8 | 3.5 |
| SBK-1014 | 152 | 240 | 36.8 | 21.0 | 17.1 | 73.7 | 23.7 | 15.8 | 5.3 | 0.5 | 7.1 | 1.9 |
| SBK-336 | 182 | 198 | 28.6 | 15.4 | 12.1 | 47.0 | 3.0 | 2.5 | 1.0 | 0.0 | 4.0 | 0.0 |
| SBK-7 | 110 | 249 | 76.4 | 12.7 | 11.8 | 59.0 | 7.2 | 6.2 | 3.8 | 0.2 | 4.3 | 0.3 |
| SBK-280 | 152 | — | 10.5 | 10.5 | 9.2 | — | — | — | 5.0 | 0.0 | — | — |
| SBK-5 | 174 | 231 | 36.8 | 9.2 | 8.0 | 53.2 | 7.8 | 6.5 | 3.2 | 0.7 | 3.5 | 0.0 |
| SBK-10 | 168 | 261 | 35.7 | 7.1 | 6.0 | 81.6 | 19.5 | 14.2 | 5.0 | 0.0 | 6.3 | 3.5 |
| SBK-9 | 110 | 210 | 63.6 | 9.1 | 5.4 | 85.7 | 21.4 | 18.6 | 4.5 | 0.7 | 6.2 | 0.5 |
| SBK-730 | 112 | — | 5.3 | 3.6 | 3.6 | — | — | — | 2.8 | 0.7 | — | — |
| SBK-8 | — | 258 | — | — | — | 53.5 | 5.8 | 5.4 | — | — | 6.0 | 2.7 |
| SBK-336 + Golden | — | 144 | — | — | — | 81.2 | 47.9 | 32.6 | — | — | 6.1 | 2.8 |
| SBK-336 + 731 | — | 159 | — | — | — | 62.3 | 24.5 | 15.7 | — | — | 4.2 | 0.5 |
| SBK-336 + Starking | — | 135 | — | — | — | 68.9 | 20.0 | 14.8 | — | — | 6.6 | 0.8 |
| SBK-3 + 8 | — | 148 | — | — | — | 74.5 | 18.1 | 14.1 | — | — | 6.6 | 1.4 |
| SBK-731 + Jonathan | — | 138 | — | — | — | 67.4 | 2.2 | 2.1 | — | — | 5.8 | 0.5 |
| Starking | 98 | 195 | 76.0 | 23.1 | 17.0 | 81.5 | 27.7 | 20.5 | 4.5 | 1.0 | 6.8 | 1.5 |
| Golden Delicious | 101 | 210 | 89.0 | 39.0 | 22.0 | 65.7 | 27.1 | 17.1 | 5.1 | 0.9 | 7.2 | 1.4 |
| Free pollination | 962 | 588 | 22.4 | 21.6 | 19.9 | 47.2 | 13.9 | 8.8 | 6.5 | 0.8 | 6.4 | 0.5 |

**Table 6**

*Effect of pollinator Malus taxa on the seed formation and the seed content of the fruits in Starking variety (Helvécia 1977–1978)*

| Code number of the Malus taxa (types) | No. of pollinated flowers | | Seed formation (%) | | | | | | No. of seeds falling to one fruit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1977 | | | 1978 | | | 1977 | | 1978 | |
| | 1977 | 1978 | I | II | III | I | II | III | full | non-full | full | non-full |
| SBK-277 | 96 | — | 62.5 | 46.5 | 37.5 | — | — | — | 4.6 | 1.0 | — | — |
| SBK-333 | 192 | — | 59.4 | 50.0 | 33.3 | — | — | — | 4.0 | 1.0 | — | — |
| SBK-1014 | 112 | — | 31.2 | 28.6 | 18.7 | — | — | — | 5.3 | 1.2 | — | — |
| SBK-10 | 182 | 48 | 33.0 | 22.0 | 18.7 | 18.7 | 12.5 | 10.4 | 5.5 | 0.0 | 4.3 | 4.0 |
| SBK-1003 | 182 | — | 25.0 | 17.7 | 13.5 | — | — | — | 6.3 | 1.0 | — | — |
| SBK-9 | 156 | 47 | 21.8 | 17.9 | 12.8 | 12.8 | 8.5 | 8.5 | 4.0 | 1.0 | 2.5 | 4.0 |
| SBK-6 | 91 | 42 | 46.1 | 15.4 | 12.1 | 4.7 | 0.0 | 0.0 | 6.6 | 0.3 | — | — |
| SBK-336 | 158 | 56 | 30.3 | 21.5 | 11.3 | 45.4 | 3.6 | 3.6 | 2.5 | 1.0 | 2.0 | 4.5 |
| SBK-726 | 126 | — | 42.8 | 14.0 | 11.0 | — | — | — | 3.0 | 0.0 | — | — |
| SBK-280 | 152 | — | 15.8 | 10.5 | 7.9 | — | — | — | 3.5 | 0.0 | — | — |
| SBK-730 | 203 | — | 30.4 | 11.8 | 7.8 | — | — | — | 3.9 | 0.8 | — | — |
| SBK-1 | 128 | 60 | 25.0 | 12.5 | 7.8 | 5.0 | 3.3 | 3.3 | 6.7 | 0.5 | 1.7 | 4.5 |
| SBK-5 | 99 | 72 | 27.3 | 9.1 | 7.1 | 0.0 | 0.0 | 0.0 | 2.0 | 3.0 | — | — |
| SBK-7 | 114 | — | 21.0 | 10.5 | 7.0 | — | — | — | 3.6 | 1.2 | — | — |
| SBK-3 | 168 | 49 | 7.1 | 3.6 | 2.4 | 14.2 | 0.0 | 0.0 | 4.6 | 0.4 | — | — |
| SBK-731 | 176 | 66 | 3.4 | 2.3 | 1.1 | 10.9 | 0.0 | 0.0 | 4.0 | 0.0 | — | — |
| Jonathan | 95 | 120 | 41.0 | 28.4 | 25.3 | 20.8 | 7.7 | 5.8 | 6.5 | 1.0 | 5.9 | 1.2 |
| Golden Delicious | 102 | 152 | 44.1 | 28.4 | 16.7 | 24.3 | 7.9 | 6.6 | 4.8 | 0.9 | 6.2 | 1.5 |
| Free pollination | 968 | 605 | 5.8 | 5 0 | 4.1 | 14.7 | 6.8 | 4.6 | 4.4 | 0.5 | 5.6 | 1.4 |

seed formation was lower in SBK-1003, SBK-731 and SBK-336, while it was higher in SBK-9 and SBK-10 taxa (types). Of pollinations with pollen mixtures, the one consisting of SBK-336 + Golden Delicious has a very remarkable effect.

In contrast with seed formation, seed content showed a better result in 1978 (Table 5). In 1977, no relationship was detected between seed content and seed formation. In 1978, in taxa (types) showing satisfactory seed formations, also the seed content was high.

Of "Starking" variety (Table 6), only two types were more outstanding than the best control variety, and in comparison with the Jonathan, the number of types showing very poor (under 10%) seed formation was higher. Of the three commercial apple varieties, the Starking ones had the poorest seed formation results in 1978. In the 4 *Malus* taxa (types) (♀), no seed at all was formed from the hybridizations, and the other taxa (types) proved also to be of very poor fertilization capacity. In this variety a longer observation period is necessary for choosing the suitable pollinators.

With respect to the Golden Delicious (♀), there was a significant difference between the results of seed formation in the two years (Table 7). The *Malus* taxa (types) producing a satisfactory seed formation in 1977, provided considerably poorer results in the next year. As against this, seed content — apart from one-two exceptions — does not in general lag behind the data relating to sexual pollination. Of the pollen mixtures, SBK-336 + Starking should be emphasized on the basis of both the seed formation and the seed content.

## Discussion

The *Malus* pollination scheme only ensures satisfactory seed formation every year and in the last instance suitable fruit if several *Malus* taxa (types) are applied simultaneously as pollinators. The greatest advantage of applying *Malus* taxa (types) as pollinators as against the conventional varieties is that it makes the joint use of several pollinators possible without having to change the agrotechnical conditions developed for the main variety. By using several *Malus* taxa (types) jointly, we can achieve that for the flowers of varieties, having their flowering stages in different periods, pollinators flowering in corresponding periods can be fully ensured.

From our fertilization biological observation, the three main commercial apple varieties — Jonathan, Golden Delicious, Starking — can be chosen as subjects of further examination to be carried out in model orchards, with respect to the taxa (types) enumerated in Table 8. The taxa (types) appearing in the top row of the Table show a flowering period to closely corresponding that of the main variety (Nyéki et al. 1980), and do not produce harmful metaxenia on the seeds or fruits. The investigation of these in model commercial orchards has been started.

The taxa (types) enumerated in the bottom row of the Table had suitable fertilization biological characteristics, but the period of their flowering did not correspond to that of the three main commercial apple varieties — in the research area — satisfactorily. In spite of this, their further examination is justified, for a changed ecological and technological conditions (for

**Table 7**

*Effect of pollinator Malus taxa on the seed formation and the seed content in the fruits of Golden Delicious variety (Helvécia 1977–1978)*

| Code No. of the Malus taxa (types) | No. of pollinated flowers | | Seed formation (%) | | | | | | No. of seed falling to one fruit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1977 | | | 1978 | | | 1977 | | 1978 | |
| | 1977 | 1978 | I | II | III | I | II | III | full | non-full | full | non-full |
| SBK-277 | 103 | — | 45.6 | 37.9 | 29.1 | — | — | — | 5.1 | 0.4 | — | — |
| SBK-10 | 117 | 224 | 68.4 | 29.9 | 20.0 | 78.6 | 5.4 | 4.5 | 4.5 | 1.5 | 6.5 | 0.5 |
| SBK-1 | 192 | 198 | 50.0 | 28.0 | 19.8 | 33.3 | 1.5 | 1.5 | 5.7 | 0.3 | 5.4 | 2.0 |
| SBK-731 | 180 | 236 | 58.9 | 20.0 | 18.9 | 36.4 | 4.2 | 3.8 | 5.0 | 0.5 | 2.5 | 0.0 |
| SBK-6 | 126 | 264 | 33.3 | 22.2 | 17.5 | 67.0 | 13.6 | 12.1 | 6.0 | 1.0 | 7.1 | 0.1 |
| SBK-3 | 114 | 201 | 42.6 | 22.8 | 17.5 | 75.6 | 20.9 | 17.9 | 6.5 | 1.5 | 7.6 | 0.4 |
| SBK-333 | 160 | — | 30.0 | 20.0 | 16.2 | — | — | — | 4.5 | 0.0 | — | — |
| SBK-5 | 102 | 258 | 26.5 | 17.6 | 13.7 | 55.8 | 8.1 | 7.0 | 5.0 | 0.5 | 6.2 | 0.8 |
| SBK-1003 | 132 | 172 | 27.3 | 18.2 | 13.6 | 80.2 | 25.6 | 21.5 | 4.5 | 1.0 | 7.0 | 0.7 |
| SBK-726 | 140 | — | 21.4 | 14.3 | 11.4 | — | — | — | 6.1 | 0.2 | — | — |
| SBK-336 | 92 | 151 | 25.0 | 14.1 | 10.9 | 49.7 | 16.6 | 13.9 | 6.0 | 1.0 | 3.0 | 0.5 |
| SBK-730 | 172 | — | 13.9 | 8.1 | 5.8 | — | — | — | 3.7 | 1.0 | — | — |
| SBK-1014 | 98 | 152 | 14.3 | 1.0 | 1.0 | 57.9 | 8.5 | 7.2 | 5.0 | 1.0 | 8.2 | 0.0 |
| SBK-280 | 112 | — | 2.7 | 0.9 | 0.9 | — | — | — | 5.0 | 0.0 | — | — |
| SBK-8 | — | 158 | — | — | — | 65.8 | 8.2 | 7.6 | — | — | 6.0 | 1.0 |
| SBK-9 | — | 225 | — | — | — | 34.7 | 8.0 | 7.1 | — | — | 8.0 | 0.3 |
| SBK-7 | — | 118 | — | — | — | 45.8 | 0.0 | 0.0 | — | — | — | — |
| SBK-336 + 731 | — | 171 | — | — | — | 24.6 | 1.2 | 1.2 | — | — | 5.2 | 2.2 |
| SBK-336 + Starking | — | 188 | — | — | — | 89.4 | 46.2 | 30.8 | — | — | 9.3 | 0.0 |
| SBK-336 + Golden | — | 123 | — | — | — | 38.2 | 7.3 | 6.5 | — | — | 6.0 | 0.0 |
| SBK-3 + 8 | — | 152 | — | — | — | 82.2 | 5.9 | 4.6 | — | — | 7.5 | 0.0 |
| Starking | 126 | 154 | 28.5 | 25.4 | 19.8 | 59.7 | 18.8 | 16.2 | 5.0 | 0.2 | 8.0 | 0.3 |
| Jonathan | 140 | 185 | 77.1 | 30.0 | 27.1 | 50.2 | 11.3 | 9.1 | 7.9 | 0.8 | 7.5 | 2.0 |
| Free pollination | 740 | 809 | 19.5 | 11.1 | 5.9 | 36.7 | 10.5 | 8.3 | 7.5 | 0.5 | 5.2 | 1.8 |

example, in chossing another kind of graft, or of grafting on to the variety) we may find that there is some overlapping in the time of flowering. The ratio between *Malus* taxa and orchard varieties may change from 1 : 5 to 1 : 11, depending on the mode of cultivation and on the fertilization capacity of the variety (SOLTÉSZ et al. 1979). In this publication several varieties were given in relation to planting *Malus* taxa with commercial varieties in spindle buch, hedges and slendir spindle orchards.

**Table 8**

*Malus taxa (types) showing satisfactory fertilization capacity when matched with main commercial apple varieties (Budapest-Soroksár, Helvécia 1977–1978)*

| Flowering period | Jonathan | Starking | Golden Delicious |
|---|---|---|---|
| Types flowering in the same period | SBK-3 (*M. purpurea*)<br>SBK-1014 (*M. dasyphylla-pumila*) | SBK-1014 (*M. dasyphylla-pumila*) | SBK-1003 (*M. domestica-pumila*) |
| Types flowering in different periods | SBK-1 (*M. purpurea*)<br>SBK-6 (*M. spectabilis*)<br>SBK-277 (*M. dasyphylla*)<br>SBK-726 (*M. silvestris*) | SBK-9 (*M. purpurea*)<br>SBK-10 (*M. halliana*)<br>SBK-277 (*M. dasyphylla*) | SBK-3 (*M. floribunda*)<br>SBK-6 (*M. spectabilis*)<br>SBK-277 (*M. dasyphylla*) |

Our research work cannot yet be considered as finished. In the future, our aim — apart from the tasks outlined earlier (NYÉKI et al. 1980) — will be to study the effect of different ecological and technological environments; to choose the *Malus* taxa (types) female sterile or showing poor fertilization capacity near commercial varieties (♀); and the clarification of susceptibility to more important bacteria and insects. For choosing several suitable taxa (types) the drawing of new types into the investigation is also necessary.

Our aim is to examine the graft effect on the strength and character of growth; the placing and ratio of *Malus* taxa (types); the effect on seed formation, fruit quality (colour, size, internal content, possibility of preservation); the quantity of produce or the ways of ensuring fruit growing; and it is here that we receive a final answer to our flowering phenological and fertilization biological questions. On the basis of all these with regard to the variety-specific agrotechniques an economic assessment of the *Malus* pollination scheme will be possible.

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# CHANGE IN THE TOTAL ALKALOID CONTENTS IN THE TISSUE CULTURES OF DATURA INNOXIA MILL. IN THE FUNCTION OF THE CULTURAL CIRCUMSTANCES

ÉVA SZŐKE, N. N. DUNG, GIZELLA VERZÁR-PETRI and ÁGNES POTOCZKI
SEMMELWEIS MEDICAL UNIVERSITY, INSTITUTE OF PHARMACOGNOSY, BUDAPEST, HUNGARY

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During the growing period the total alkaloid contents of the callus tissues of different origin (of root, leaf, corolla, gynoeceum) was examined simultaneously with the biomass production. It has been observed that the alkaloid content is high in the first two weeks of growth and then it slowly decreases when the growth of the tissues becomes intensive. At the end of the growing period, at the period of the stabilization of the tissues it rises again.

Analyzing the influence of the concentration of the growth regulating substances it has been established that under the influence of high kinetic concentration the alkaloid production is impeded. But under the influence of 5 mg/l 2,4-D the alkaloid contents suddenly rose. In case of callus tissues of root origin it reached the alkaloid quantity formed in the intact root.

Under the influence of illumination the alkaloid contents of the callus tissues of root and leaf origin rise twofold as compared to the cultures grown in dark.

## Introduction

Nowadays experiments are increasingly tried in order to produce materials of natural origin not only by organic chemical synthesis but also by biological methods, through so-termed biological production. This is why the application of the plant tissue production as a method has become wide-spread for the purpose of studying the formation of the secondary metabolic products, mainly of the alkaloids and also with a view to their directed production of effective agents. Furthermore, the isolated plant tissue production has several advantages as compared to the classic methods of cytologic, histological or biological examinations. It can be applied everywhere because it is independent of the outdoor natural circumstances. Making use of it, physical and chemical factors exercising an influence on the vital processes can be examined, separated and checked; and the experiments on reproduction can be performed relatively quickly and repeated several times.

Many of the publications relating to the study of the biosynthesis of the tropan-alkaloids deal with the callus tissues of *Datura innoxia* Mill. and the alkaloid production thereof (BEREZNEGOVSKAYA et al. 1978; COSSON 1969; HIRAOKA and TABATA 1974; STABA and JINDRA 1968; SMORODIN 1974, etc.). HIRAOKA and TABATA produced callus tissues from different organs (root, stem, embryo, anther) of *Datura innoxia.* They studied intensively the biological, physical and chemical factors which exercise an influence on the growth and alkaloid production of the tissue cultures. The total alkaloid content of the callus tissues produced by them was smaller than that of the intact plants. The grown cells showed a stronger growth in suspension cultures than in static ones but the alkaloid production was almost the same with both of their growing methods. Various clones showing no considerable

deviation as regards their alkaloid contents were also produced from the callus tissues of *Datura innoxia*, but characteristic differences could be seen as regards e.g. growth, chlorophyll contents and capability for organogenesis. HIRAOKA furthermore established (1976) that the growth of the tissues as regards alkaloid production proved to be optimum when using a 3% sugar concentration, while by adding peptone or yeast extract the alkaloid contents of *Datura* tissue cultures increases considerably. According to his examinations light hardly exercises an influence on the alkaloid production of the *Datura* tissues. Analyzing the influence of the growth regulating substances he established that both 2,4-D and NAA promoted the increase of the callus tissues but kinetin is not needed for the biomass production and, in great concentration, it impedes more or less the alkaloid production.

During our examinations we, too, examined the growth and alkaloid production of the tissues mainly in the function of the concentration of growth regulating substances. Furthermore an analysis is given on how the biomass production and total alkaloid contents, respectively, of the tissues change in dark and under the influence of illumination, respectively, during the growing period.

Account is given of our growth dynamic examinations in our previous publications (DUNG, SZŐKE and VERZÁR-PETRI 1981, POTOCZKI, SZŐKE and VERZÁR-PETRI 1982).

## Material and methods

Our tissue cultures were produced from the root, leaf and flower (corolla, gynoeceum) of *Datura innoxia* Mill. The callus tissues were grown in dark and in light (2500 Lux, 10 hours/day) at 26 °C in a basic nutrient medium of MURASHIGE–SKOOG in mineral and vitamin composition, containing 1 mg/l of kinetin and 1 mg/l of 2,4-D.

The growth regulating substances exercised the most interesting influence on the character of the growth of the tissues, as compared to the cultures grown on basic media, with the following proportion of supply:

| | |
|---|---|
| 0 mg/l kinetin; | 1 mg/l 2,4-D |
| 2 mg/l ,, | 1 mg/l 2,4-D |
| 5 mg/l ,, | 1 mg/l 2,4-D |
| 1 mg/l ,, | 2 mg/l 2,4-D |
| 1 mg/l ,, | 5 mg/l 2,4-D |

Consequently, in this work the results are given which have been obtained during the determination of the total alkaloid contents of different *Datura* cultures grown on nutrient media made by the supply of growth regulating substances in the above proportions.

The callus tissues were grafted into fresh media every sixth week. The callus tissues of root and leaf origin are six year old cultures, those of corolla and gynoeceum origin are 4 year old which are equally built up of loose, homogeneous parenchymatic cells and are similar as regards their external morphology.

Account has already been given previously of our cytologic and histochemical observations, too (VERZÁR-PETRI, SZŐKE, DUNG, POTOCZKI, in press).

To determine the total alkaloid contents, lyophilized tissues have been used. After an ammonical disengagement the alkaloids were extracted cold with methanol, by a homogenizator of 12,000 revolutions per minute and then, after a vitriolic purification, they were determined photometrically, as regards their quantity, in a medium containing chloroform, by tropeolin 000 amphiindicator (by adapting the method of 1961 of LŐRINCZ and SZÁSZ). This method has proved to be sensitive enough to measure the low alkaloid concentration of the tissue cultures, too. The total alkaloid content is given as expressed in skopolaminbase, related to dry weight.

## Results and evaluation of the experiments

Analyzing the total alkaloid contents of the callus tissues of root, leaf, corolla and gynoeceum origin grown in dark on the basic medium (1 mg/l

**Table 1**

*Changes in the total alkaloid contents of callus tissues during the growing period*

| | Alkaloid contents of the callus tissue (%) (related to dry weight) | | | | Alkaloid contents of the intact tissue (%) |
|---|---|---|---|---|---|
| | 2 weeks | 4 weeks | 6 weeks | 8 weeks | |
| Root | 0.169 | 0.104 | 0.043 | 0.125 | 0.330 |
| Leaf | 0.122 | 0.077 | 0.041 | 0.096 | 0.250 |
| Corolla | 0.071 | 0.149 | 0.086 | 0.080 | 0.470 |
| Gynoeceum | 0.049 | 0.033 | 0.730 | 0.065 | 1.263 |

kinetin and 1 mg/l 2,4-D) we came to the result that the callus tissues of root origin have the highest total alkaloid contents while those of gynoeceum origin have the lowest one (Table 2).

Studying the change in the total alkaloid contents of callus tissues of different origin (Table 1) — simultaneously with the biomass formation — during the growing period (tissues of different age: of 2, 4, 6, 8 weeks) we observed that at the growing period (between 0–2 weeks) the alkaloid content was relatively high and then it decreased gradually when the growth of the tissues became intensive. In the last period of growing, when the growth of the tissues is slowing down and entirely stops, respectively, the alkaloid content is rising again. This tendency can be observed in case of the callus tissues of root, leaf and gynoeceum origin (Figs 1, 2, 3). With the only difference that the speed of growth (mg/day) of the callus tissues of root and leaf origin hits the peak in the sixth week so the alkaloid content is the lowest at

**Table 2**

*The effect of growth regulators on the total alkaloid contents of callus tissues*

| Growth regulator, mg/l | | Alkaloid contents of the callus tissue (%) (related to dry weight) | | | |
|---|---|---|---|---|---|
| kinetin | 2,4-D | root | leaf | corolla | gynoeceum |
| 0 | 1 | 0.002 | 0.001 | 0.018 | — |
| 1 | 1 | 0.125 | 0.096 | 0.086 | 0.073 |
| 2 | 1 | 0.055 | 0.050 | 0.025 | 0.030 |
| 5 | 1 | 0.014 | 0.046 | 0.018 | 0.020 |
| 1 | 2 | 0.048 | 0.049 | 0.023 | 0.028 |
| 1 | 5 | 0.334 | 0.227 | 0.055 | 0.053 |
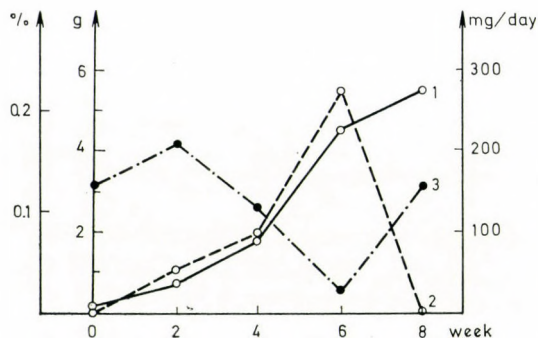
*Fig. 1.* Formation of total alkaloid contents and biomass production in the callus tissues of root origin of *Datura innoxia* Mill. during the growing period. — 1: fresh weight of callus tissue (g) — 2: growth speed (mg/day) — 3: alkaloid contents (%)
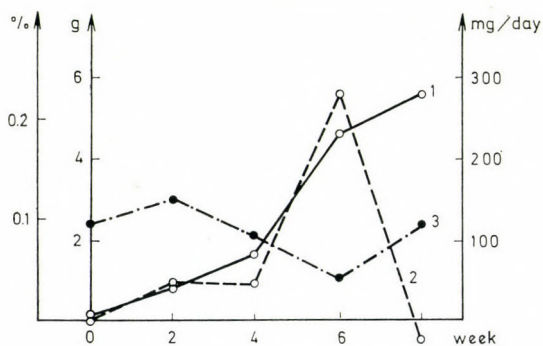
*Fig. 2.* Formation of total alkaloid contents and biomass production in the callus tissues of leaf origin of *Datura innoxia* Mill. during the growing period. (The meaning of the signs and symbols see in Fig. 1)
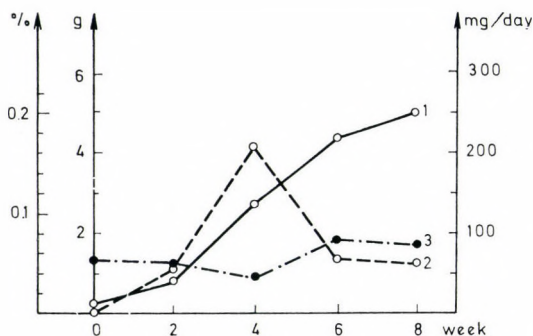
*Fig. 3.* Formation of total alkaloid contents and biomass production in the callus tissues of gynoeceum origin of *Datura innoxia* Mill. during the growing period. (The meaning of the signs and symbols see in Fig. 1)
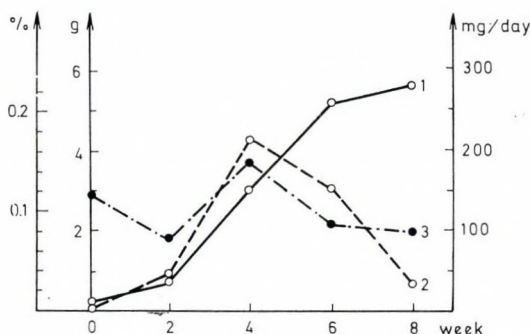
*Fig. 4.* Formation of total alkaloid contents and biomass production in the callus tissues of corolla origin of *Datura innoxia* Mill. during the growing period. (The meaning of the signs and symbols see in Fig. 1)

this time (Figs 1, 2) while the daily growth of the tissues of gynoeceum origin is most intensive in the fourth week so the alkaloid content slows down already earlier. The tendency described above could not be observed positively in case of cultures of corolla origin (Fig. 4).

During our further examinations the total alkaloid contents of the callus tissues grown in a medium containing kinetin and 2,4-D in different concentrations were analyzed (Table 2). It has been established that, as compared to the tissues grown on the basic medium, a medium of higher kinetin concentration (2 and 5 mg/l) impedes not only the growth of the tissues but the quantity of alkaloid also decreases (Figs 5–8). It is to be remarked that HIRAOKA, too, gives account of similar results in his dissertation (1976). We tried to grow the tissues in a medium free from kinetin and succeeded in

**Table 3**

*The effect of illumination on the total alkaloid contents of callus tissues*

| | Kinetin | 2,4-D | Illumination | Alkaloid contents (%) (related to dry weight) of the callus tissue cultures | of the intact organ |
|---|---|---|---|---|---|
| Root | 1 | 1 | dark | 0.125 | 0.330 |
| | 1 | 1 | light | 0.259 | |
| | 1 | 5 | dark | 0.334 | |
| | 1 | 5 | light | 0.264 | |
| Leaf | 1 | 1 | dark | 0.096 | 0.250 |
| | 1 | 1 | light | 0.173 | |
| | 1 | 5 | dark | 0.227 | |
| | 1 | 5 | light | 0.313 | |
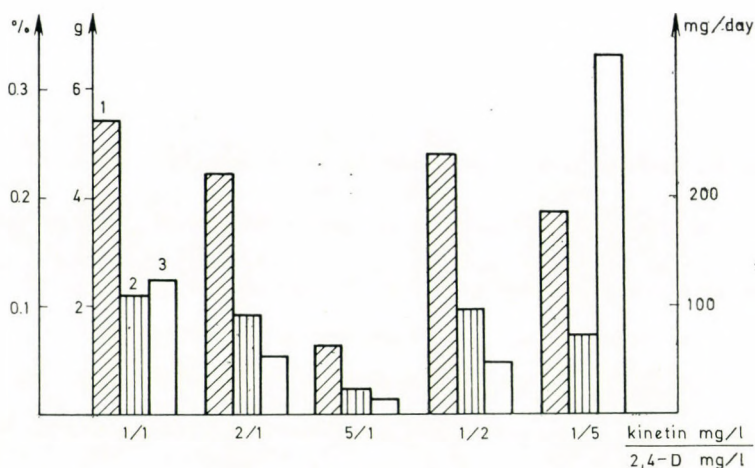
*Fig. 5.* Influence of the growth regulating substances on the total alkaloid contents of the callus tissues of root origin of *Datura innoxia* Mill. (The meaning of the signs and symbols see in Fig. 6)

producing stocks which grew extremely well also without kinetin but their alkaloid contents were minimum (Table 2).

When the 2,4-D concentration was increased in the medium however, the growth of the tissues was impeded, at the same time, under the influence of 5 mg/l 2,4-D concentration the alkaloid contents increased by leaps and bounds, especially in case of callus tissues of root and leaf origin (Figs 5 and 6). It is very remarkable that the alkaloid contents of the callus tissues of root
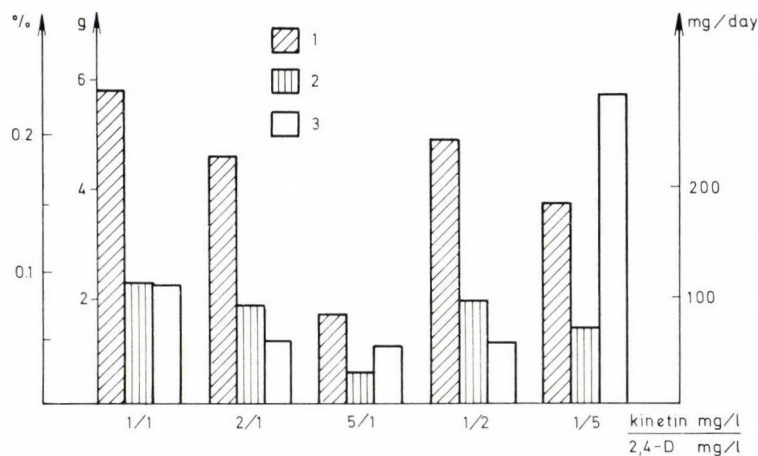
*Fig. 6.* Influence of the growth regulating substances on the alkaloid contents of the callus tissues of leaf origin of *Datura innoxia* Mill. — 1: fresh weight of the callus tissues in g — 2: growth speed in mg/day — 3: alkaloid contents in %
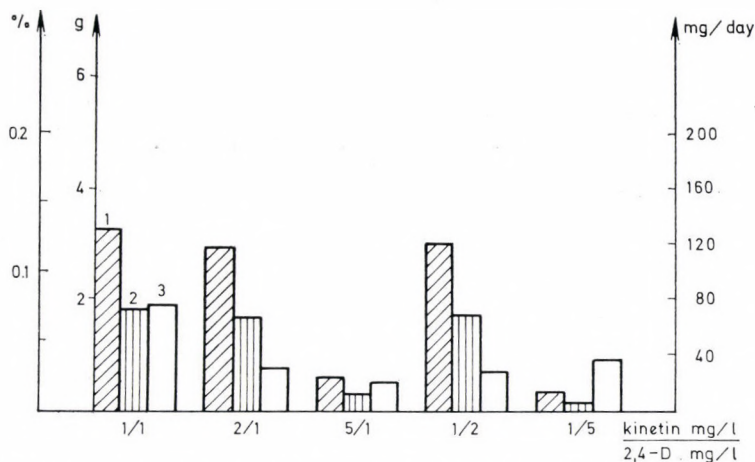
*Fig. 7.* Influence of the growth regulating substances on the total alkaloid contents of the callus tissues of gynoeceum origin of *Datura innoxia* Mill. (The meaning of the signs and symbols see in Fig. 6)

origin reached on this nutrient medium the alkaloid quantity formed in the intact roots (Table 3).

For the analysis of the effect of illumination on the alkaloid production of the tissues, callus tissues of root and leaf origin grown on basic media and on other ones containing 5 mg/l 2,4-D, were examined.

The results showed that under the influence of light the alkaloid production of the tissues becomes more intensive. In case of callus cultures grown on basic media the alkaloid content rises almost twofold.
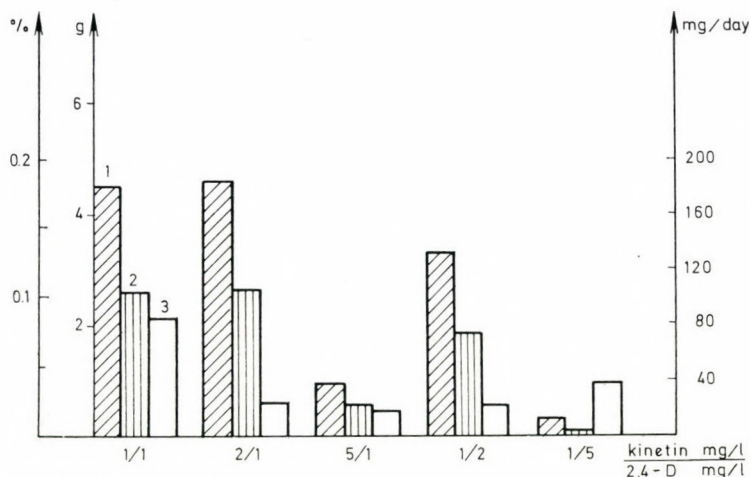
*Fig. 8.* Influence of the growth regulating substances on the alkaloid contents of the callus tissues of corolla origin of *Datura innoxia* Mill. (The meaning of the signs and symbols see in Fig. 6)

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# PRODUCTIVITY AND TURNOVER OF XEROTHERM LICHEN SPECIES

Klara P. Verseghy

BOTANICAL DEPARTMENT OF THE HUNGARIAN NATURAL HISTORY MUSEUM, BUDAPEST

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The productivity of the total-lichens of the perennial *Festucetum vaginatae* and annual *Brometum tectorum* grassland communities as well as that of the two dominating lichen species of these associations, the *Cladonia furcata* and *Cladonia magyarica*, furthermore the turnover rate and time of the lichen-phytomass and that of the mineral substances have been studied by the author. The latter is higher in the perennial grassland and lower in the annual. In each periods (growing and winter-periods) both the phytomass-changes and the turnover rate of the mineral substances are influenced not by the respective seasons but by the changeable weather factors. The turnover time of the lichen phytomass is much more longer than that of the mineral substances.

## Introduction

The productivity of lichens was first expressed by the growth rate, at this time the growth of the length or periphery of the thallus was measured. Mainly epiphyton crustose and foliose lichens were studied, generally in a year's time (Smith 1921, Tobler 1925, Abbayes 1951, Beschel 1954, Hale 1954, 1959). In the studied types of the crustose and foliose lichens the individual can be easily separated and their dimensions are important only in two dimensions, the third dimension can be neglected (e.g. *Parmelia*, *Peltigera*, *Caloplaca* species). On the other hand the study of the fruticose types well developing in three dimensions is much more difficult (e.g. *Cladonia*, *Stereocaulon* or *Ramalina* species). Kärenlampi (1970, 1971) elaborated different methods for the determination of the productivity of the fruticose lichens. It was he who first applied the relative growing rate (RGR) calculated from the dry weight in the lichens. Another method to calculate the productivity is based on the age of the thallus. The age of the fruticose lichens, such as the reindeer-lichen group, "*Cladonia stellaris, Cl. rangiferina*", etc. had been established earlier by Andreew (1954), from the number of the nodi. This method was developed further by Kärenlampi and his measurements included the length and diameter of the thallus, the length of the internodi, the weight of the thallus and the distribution of the weight in the thallus. According to his conclusion the relative growing rate of an older plant is much more lower than that of a younger one in spite of the fact that the older plant is much more longer than the younger one but only its apical parts are growing.

## Material and method

The seasonal change of the lichen phytomass was studied first in a growing period then through two years, by taking samples continuously every two months in the nature conservation area near Csévharaszt, which is one of the most characteristic area of the Great Hungarian Plain, the arenicolous wooded steppe of the Danube–Tisza Interfluve. In the area the *Festucetum vaginatae danubiale* occurs most frequently while the *Brometum tectorum secaletosum* and the *Festucetum wagneri* associations the cenological, phanerogamic taxonomical, production-biological, genetical, soil biological results of examinations of which have

been described in several works (SIMON 1971, SIMON and K. LÁNG 1968, K. LÁNG 1970, 1974, K. LÁNG and SZABÓ 1971, HORVÁTH 1970, 1973, HORÁNSZKY 1970) can be found less frequently.

The quantity and role of the lichens in the sandy grassland communities forming this natural successional row is very significant that is why the production (VERSEGHY and K. LÁNG 1971, VERSEGHY 1977), productivity (VERSEGHY 1978), turnover of material exchange (K. LÁNG and VERSEGHY 1974, VERSEGHY and K. LÁNG 1975), seasonal change of the chlorophyl contents of the total-lichens of the individual associations as well as those of the individual lichen species have been studied as a part of the production investigation of these communities.

The samples were taken from two grassland communities, the annual *Brometum tectorum secaletosum* and *Festucetum vaginatae danubiale* associations by 11 adjoining monoliths of $20 \times 20 \times 20$ cms. The material of the monoliths was separated into phanerogamic and cryptogamic components, above and under ground parts, respectively. The lichens were measured as separated into species, in air-dry state. The lichen species occurring in the two associations are: *Cladonia furcata* (Hds.) Schrad., *Cladonia magyarica* Vain., *Cladonia convoluta* Lam., *Parmelia pokornyi* (Körb.) Szat. and *Diploschistes scruposus* (Schreb.) Norm. var. *arenaria* (Schaer.) Müll. Arg.

The productivity of the lichens was calculated on the basis of the formula $w_2 - w_1 / t_2 - t_1$ (BLACKMAN 1919), according to which productivity equals the increase of weight or loss of weight obtained in a unit of time ($w$ = dry weight, $t$ = time of taking samples).

To determine the mineral contents samples were being taken continuously every two months from November, 1970 to April, 1972). The air-dry plant material was lysed according to KJELDAHL in each species.

After being freed from sulphate, $K^+$ and $Ca^{++}$ were determined by flame-photometry while the total-N contents was determined by titration, after a release by steam distillation. The results of measurement were given in mg% value related to the contents of dry material of the lichens, which value was related to a product to be found in 1 $m^2$ in a certain time.

Calculations relating to the production of the lichen phytomass and turnover rate and time of the mineral substances were made according to ROBERTSON (1957) and PRÉCSÉNYI (1971). The turnover rate of the phytomass and mineral substances was calculated on the basis of the samples taken monthly as in the lichens manifold incorporations and decompositions can be observed during a longer period, e.g. a year and if the turnover is calculated for a year — with the two extreme values being taken into consideration — the intermediate processes get lost.

The turnover of both the phytomass and the mineral substances was calculated as related to 1 $m^2$, for the total-lichens of the annual *Brometum tectorum* and perennial *Festucetum vaginatae* associations as well as for the dominating lichen species, the *Cladonia furcata* and the *Cl. magyarica* of the two grassland communities.

## Results

### *The productivity of the lichen phytomass*

Studying the productivity of the lichens of our grassland associations in 3 growing and 2 winter-periods it can be established that the direction of the processes — either related to the individual months or periods — is always the same in the two communities.

In the *Brometum tectorum secaletosum* the growing period, mainly the spring and autumn of 1968 was characterized by a strong growth process to such an extent that the decomposition lasting from June to September hardly exercised an influence on it (Table 2).

The lichens of the open, annual sandy grassland suffered much more on account of the droughty summer of 1972 than those living in the perennial *Festucetum vaginatae*. In the whole growing period the decomposing processes were predominant but their rate, strangely, was higher in spring and autumn than in summer.

In the growing period of 1972 a slighter decomposition presented itself only in the spring months then, in summer, it was followed by a growth of lesser extent and then, in autumn, by a growth of higher extent. Thus the total productivity of the period was also positive.

The two studied winter-periods differ considerably from each other both in the direction and the extent of the processes. In the winter of 1970–71 a decomposition of large extent

**Table 1**

*Values of total-lichen productivity in the Festucetum vaginatae grassland community ($g/m^2/day$)*

| Number of days between samplings | Productivity | Number of days between samplings | Productivity | Number of days between samplings | Productivity |
|---|---|---|---|---|---|
| | | growing period | | | |
| 1968 | | 1971 | | 1972 | |
| IV–V | | IV–V | | IV–VI | |
| 27 | −3.33 | 35 | −2.03 | 58 | −0.46 |
| V–VI | | V–VI | | | |
| 29 | −1.65 | 42 | −0.45 | | |
| VI–VII | | VI–VII | | VI–IX | |
| 32 | +0.37 | 20 | +2.35 | 84 | −0.22 |
| VII–VIII | | VII–VIII | | | |
| 39 | −0.41 | 28 | −1.43 | | |
| VIII–IX | | VIII–IX | | | |
| 13 | −0.23 | 32 | +1.31 | | |
| IX–X | | IX–X | | IX–X | |
| 28 | +3.93 | 26 | −1.65 | 37 | +6.56 |
| Total productivity | −1.32 | | −1.90 | | +5.88 |
| | | winter period | | | |
| 1970–71 | | 1971–72 | | 1972 | |
| | | X–XI | | X–XII | |
| | | 28 | +0.96 | 62 | −2.33 |
| XI–XII | | XI–XII | | | |
| 17 | −6.76 | 64 | +0.66 | | |
| XII–I | | | | | |
| 42 | −0.38 | | | | |
| I–II | | I–II | | | |
| 25 | −2.40 | 41 | +0.58 | | |
| II–III | | II–III | | | |
| 32 | −0.78 | 30 | +1.97 | | |
| III–IV | | III–IV | | | |
| 25 | +0.48 | 28 | −4.46 | | |
| Total productivity | −9.84 | | −0.29 | | |

took place in the lichen fraction of the *Brometum* while in the winter of 1971–72 a slow growth could be observed which, however, was followed in April by decomposing processes but the total productivity of the period remained positive after all (Table 2).

In the growing period of 1968 the decomposing processes predominated in the lichen fraction of the *Festucetum vaginatae* association and these processes could not be counter-

**Table 2**

*Values of total-lichen productivity in the Brometum secaletosum grassland community (mg/m²/day)*

| Number of days between samplings | Productivity | Number of days between samplings | Productivity | Number of days between samplings | Productivity |
|---|---|---|---|---|---|
| growing period | | | | | |
| 1968 | | 1971 | | 1972 | |
| IV–V 27 | +5.14 | IV–V 35 | −2.06 | IV–VI 58 | −0.38 |
| V–VI 29 | +0.20 | V–VI 42 | −0.43 | | |
| VI–VII 32 | −1.34 | VI–VII 20 | −0.05 | VI–IX 84 | +0.59 |
| VII–VIII 39 | −0.28 | VII–VIII 28 | +0.93 | | |
| VIII–IX 13 | −0.76 | VIII–IX 32 | 0 | | |
| IX–X 28 | +4.42 | IX–X 26 | −0.54 | IX–X 37 | +2.30 |
| Total productivity | +7.38 | | −2.15 | | +2.51 |
| winter period | | | | | |
| 1970–71 | | 1971–72 | | 1972 | |
| | | X–XI 28 | +0.57 | X–XII 62 | +0.16 |
| XI–XII 17 | −6.65 | XI–I 64 | +0.64 | | |
| XII–I 42 | −1.05 | | | | |
| I–II 25 | −5.88 | I–II 41 | +0.54 | | |
| II–III 32 | +1.37 | II–III 30 | +0.83 | | |
| III–IV 25 | −1.24 | III–IV 28 | −1.21 | | |
| Total productivity | −13.45 | | +1.37 | | |

balanced either with a growth of larger extent. Thus the whole period ended with a negative sign (Table 1).

In May and June, 1971 the decomposing process was of similar extent than that of the *Brometum* but in July and September, however, a considerable growth took place. In spite of it the total productivity is negative here, too, by the end of the growing period.

**Table 3**

*Values of productivity of Cladonia magyarica and Cl. furcata in the Brometum tectorum grassland community ($g/m^2/day$)*

| Number of days between samplings | Productivity of | | Number of days between samplings | Productivity of | |
|---|---|---|---|---|---|
| | *Cl. magyarica* | *Cl. furcata* | | *Cl. magyarica* | *Cl. furcata* |
| growing period | | | | | |
| 1971 | | | 1972 | | |
| IV–V 35 | — | −0.34 | | | |
| V–VI 43 | — | −0.28 | IV–VI 58 | — | −0.10 |
| VI–VII 20 | −0.22 | | | | |
| | (IV–VII) 98 | +0.50 | | | |
| VII–VIII 28 | +0.25 | +0.64 | VI–IX 84 | — | +0.05 |
| VIII–IX 32 | +0.09 | −0.12 | | | |
| IX–X 26 | −0.46 | −0.04 | IX–X 37 | +0.67 | +0.11 |
| | | | | (IV–X) 119 | |
| Total productivity | −0.34 | +0.36 | | +0.67 | +0.06 |
| winter period | | | | | |
| 1970–71 | | | 1971–72 | | |
| | | | X–XI 28 | +0.32 | +0.32 |
| XI–XII 17 | −1.76 | −4.58 | XI–I 64 | +0.12 | +0.56 |
| XII–I 42 | −0.47 | −2.02 | | | |
| I–II 25 | +0.68 | −4.32 | I–II 41 | +0.22 | +0.34 |
| II–III 32 | +0.38 | −0.81 | II–III 30 | +0.93 | −0.10 |
| III–IV 25 | −0.76 | −0.20 | III–IV 28 | −1.28 | −0.03 |
| Total productivity | −1.97 | −11.93 | | +0.31 | +1.09 |

From April to September, 1972 again decomposing processes of small extent were predominating but in October it was followed by a very strong growth which made the productivity value of the period positive.

**Table 4**

*Values of productivity of Cladonia magyarica and Cl. furcata in Festucetum vaginatae grassland community (g/m²/day)*

| Number of days between samplings | Productivity of | | Number of days between samplings | Productivity of | |
|---|---|---|---|---|---|
| | *Cl. magyarica* | *Cl. furcata* | | *Cl. magyarica* | *Cl. furcata* |
| | | growing period | | | |
| | 1971 | | | 1972 | |
| IV–V 35 | −0.28 | −0.60 | IV–VI 58 | −0.38 | +0.29 |
| V–VI 42 | −0.02 | +0.02 | | | |
| VI–VII 20 | −0.10 | +0.35 | VI–IX 84 | −0.03 | +0.08 |
| VII–VIII 28 | −0.14 | +0.57 | | | |
| VIII–IX 32 | +1.37 | −0.59 | | | |
| IX–X 26 | −2.11 | +0.15 | IX–X 37 | +3.35 | 0.00 |
| Total productivity | −1.28 | −0.10 | | +2.94 | +0.37 |
| | | winter period | | | |
| | 1970–71 | | | 1971–72 | |
| | | | X–XI 28 | +0.28 | +0.18 |
| XI–XII 17 | −4.00 | −2.23 | XI–I 64 | +0.45 | −0.03 |
| XII–I 42 | −1.52 | −1.42 | | | |
| I–II 25 | −0.16 | +0.96 | I–II 41 | +0.36 | +0.41 |
| II–III 32 | −0.44 | +0.40 | II–III 30 | +1.43 | +0.36 |
| III–IV 25 | −0.08 | −1.76 | III–IV 28 | −2.75 | −1.18 |
| Total productivity | −6.20 | −4.05 | | −0.23 | −0.26 |

The direction and extent of the studied two winter-periods, too, are similar to those of the lichens living in the *Brometum*. The winter of 1970–71 can be characterized by a strong decomposition-although it is of lesser extent in the *Brometum*. In the winter of 1971–72 the growth processes came to the front, but here the decomposition in April was of such a large extent that the value of total productivity, too, turned out negative (Table 1).

Studying the productivity of the individual species, the productivity of two predominating lichen species, the *Cladonia magyarica* and *Cl. furcata* was analysed in the period from November, 1970 to December 1972 (Tables 3, 4).

Both in the growing and the winter periods the productivity of the *Cladonia magyarica* is of smaller extent in the *Brometum* than in the *Festucetum*.

The *Cladonia furcata* was characterized by more balanced processes in the growing period. In the winter period the extent of the processes is more stronger in the *Brometum* while it is less intensive in the *Festucetum* (Tables 3, 4).

On surveying the Tables it can also be established that in the same community the individual species are not increasing or decreasing identically every month. In the individual periods the values of total-productivity of the species are, except one case, of the same sign; e.g. in the *Brometum* the total productivity of the *Cladonia magyarica* and *Cl. furcata* is negative in the winter period of 1970–71 while it is positive in the winter of 1971–72. In the *Festucetum* negative values were obtained for both species, in both of the winter periods.

## Turnover of lichen phytomass

Comparing the turnover rate of the total-lichen phytomass of the annual *Brometum* and perennial *Festucetum vaginatae* associations it can be established that the turnover rate is lower in the *Brometum*, consequently the turnover time is longer and slower, respectively, than that of the *Festucetum vaginatae* association (Figs 1, 2; Table 5).

The turnover rate differs in the predominating lichen species (*Cladonia magyarica*, *Cladonia furcata*) of the two communities. The turnover rate of the phytomass of the *Cladonia furcata* living in large numbers in the *Brometum* is low (Fig. 3) and its turnover time is rather long (9, 12, 17 years) (Table 5). The same species is of smaller importance in the *Festucetum*, the intensity of the processes — either incorporation or decomposition is being taken into consideration — is much more higher than in the former (Fig. 4), the turnover time ranges from 1 to 2.3 years.
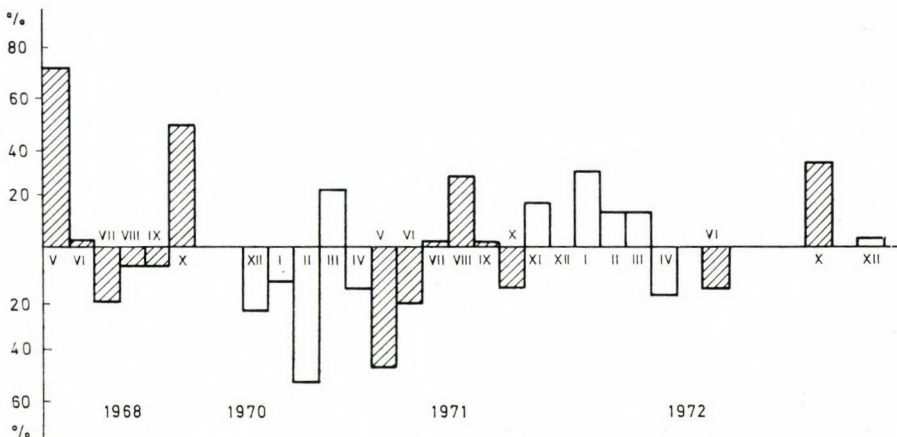
*Fig. 1.* Turnover rate of the total lichen phytomass in the *Brometum tectorum* association

On the other hand the turnover rate of the phytomass of *Cladonia magyarica* is of lesser extent in the *Festucetum vaginatae* than in the *Brometum* (Figs 5 and 6), the turnover time ranges from 0.9 to 2.1 years in the latter

**Table 5**

*Comparative table of values of turnover time of phytomass and mineral substances in the growing and winter period*

| | In *Festucetum vaginatae* | | | | In *Brometum tectorum* | | | |
|---|---|---|---|---|---|---|---|---|
| | 1970–71 XI–IV | 1971–72 XI–IV | 1971 V–X | 1970 XI–1971 XI | 1970–71 XI–IV | 1971–72 XI–IV | 1971 V–X | 1970 XI–1971 X |
| | winter period | | growing period | the whole year | winter period | | growing period | the whole year |
| Total lichen | | | | | | | | |
| Phytomass | 4.18 | 1.92 | 1.49 | 5.30 | 2.37 | 2.87 | 6.90 | 9.37 |
| Total N | 0.63 | 0.80 | 1.16 | 1.16 | 0.70 | 1.07 | 1.72 | 1.24 |
| Ca | 0.59 | 0.76 | 0.83 | 1.11 | 0.56 | 0.60 | 0.99 | 1.10 |
| K | 0.66 | 0.76 | 0.67 | 1.08 | 0.58 | 0.94 | 1.87 | 1.14 |
| *Cladonia magyarica* | | | | | | | | |
| Phytomass | 4.28 | 1.44 | 4.52 | 8.39 | 1.28 | 0.92 | 0.94 | 2.18 |
| Total N | 0.63 | 0.65 | 0.71 | 1.15 | 0.71 | 0.56 | 0.62 | 1.04 |
| Ca | 0.57 | 0.63 | 0.65 | 1.07 | 0.56 | 0.52 | 0.54 | 1.02 |
| K | 0.61 | 0.53 | 0.67 | 1.10 | 0.72 | 0.56 | 0.60 | 1.03 |
| *Cladonia furcata* | | | | | | | | |
| Phytomass | 1.38 | 1.79 | 0.93 | 2.35 | 2.95 | 19.17 | 9.41 | 12.61 |
| Total N | 0.61 | 0.63 | 0.55 | 1.03 | 0.64 | 1.10 | 1.52 | 1.21 |
| Ca | 0.59 | 0.60 | 0.54 | 1.01 | 0.55 | 0.61 | 1.43 | 1.09 |
| K | 0.60 | 0.66 | 0.54 | 1.01 | 0.50 | 1.03 | 2.29 | 1.14 |
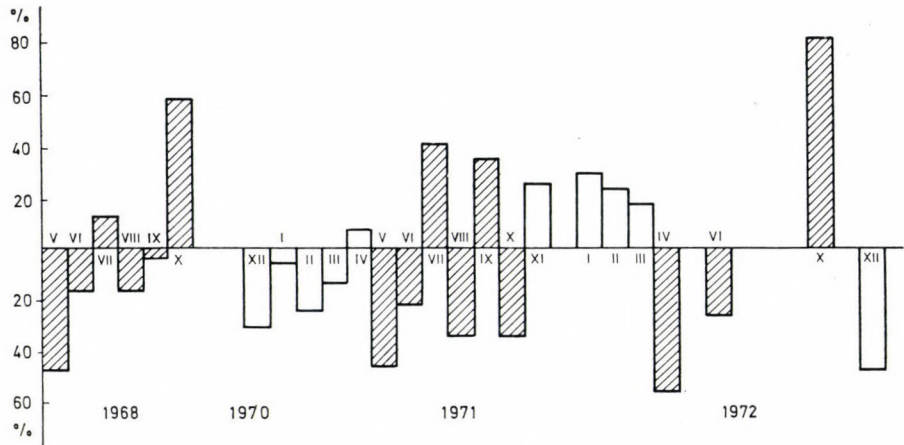
*Fig. 2.* Turnover rate of the total-lichen phytomass in the *Festucetum vaginatae* association

while it increases multiple in the *Festucetum*. From all these the conclusion can be drawn that the turnover rate of the phytomass of the predominating lichen species in great numbers in the association is lower, the turnover time is longer and slower, respectively, than those of the accompanying species.

In the individual species the period of incorporation and decomposition agree with the results obtained from the total lichens of the association, thus the winter of 1970–71 was the period of decomposition while the winter of 1971–72, that of incorporation.
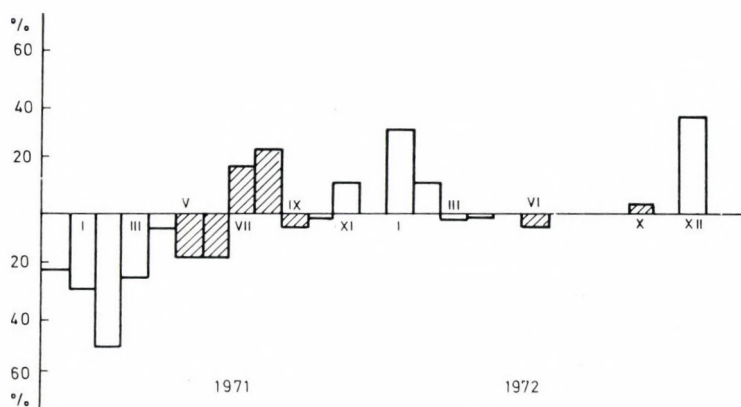
*Fig. 3.* Turnover rate of the phytomass of *Cladonia furcata* in the *Brometum* association
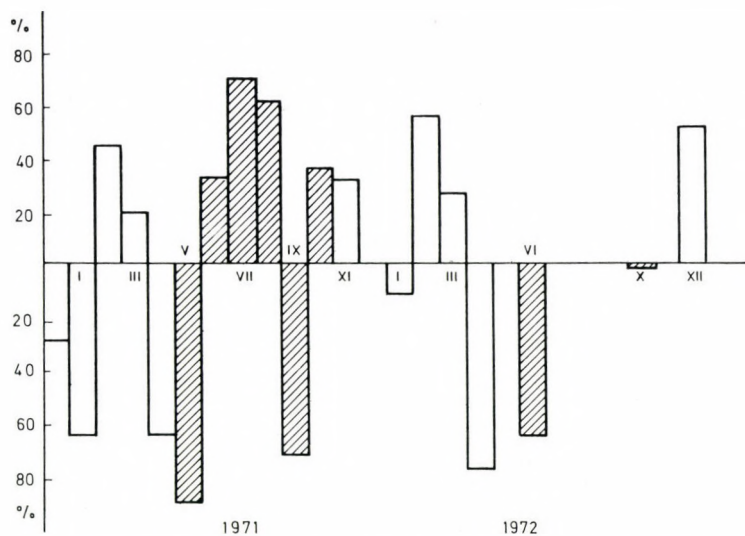
*Fig. 4.* Turnover rate of the phytomass of *Cladonia furcata* in the *Festucetum vaginatae* association

## Turnover of the mineral substances

In the turnover of mineral substances of the studied communities (*Festucetum vaginatae, Brometum tectorum*) the dynamics of N, K, Ca and P has been dealt with (K. LÁNG 1974).

The lichen fraction constitutes a considerable part of the phytomass in both communities that is why the seasonal change of K, Ca and total-N
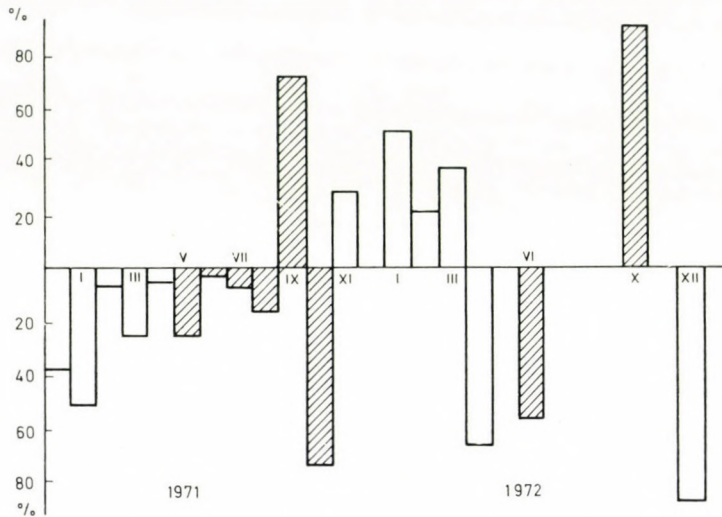
*Fig. 5.* Turnover rate of the phytomass of *Cladonia magyarica* in the *Festucetum vaginatae* association
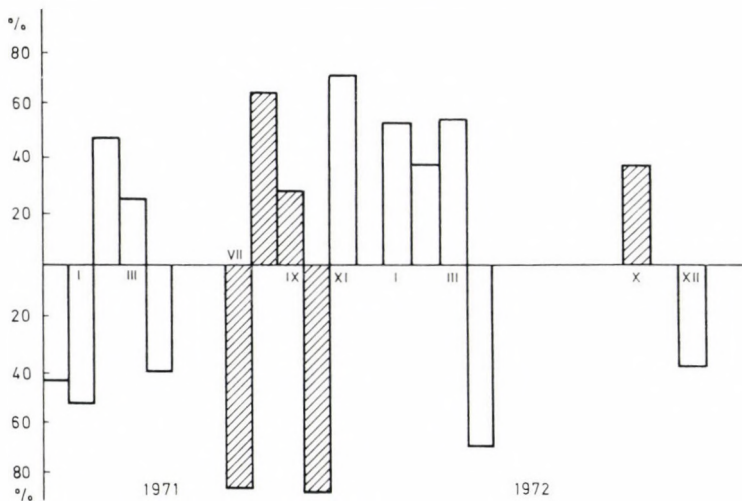
*Fig. 6.* Turnover rate of the phytomass of *Cladonia magyarica* in the *Brometum tectorum* association

contents of the lichens, the part of the lichens in K, Ca and N turnover of the associations (KOVÁCS-LÁNG and VERSEGHY 1974, VERSEGHY and KOVÁCS-LÁNG 1975), as well as the seasonal change of their phosphor contents in the growing period (KOVÁCS-LÁNG 1974) were studied through two years.

The role of the lichens in the phosphor turnover of the swards is not important as only one part, some 6–8% of the phosphor incorporated in the phytomass can be found in this fraction. The reason of the low P contents can be found in the lack of the apothecia and low P contents of the substratum. The *Cladonia furcata* and *Cl. magyarica* occurring in great numbers from the species of lichen fraction live without apothecium in the greater part of the year, the *Cladonia convoluta* and the *Parmelia pokornyi* do not produce apothecia in this site at all.

In the turnover of mineral substances of the studied sandy grasslands the part of the lichens is important mainly in the Ca-turnover. The Ca-contents of the lichens is much more higher than that of the Graminea species constituting an association with them. The contents of the other studied elements, K, P and total-N are lower in the lichens than in the grasses constituting an association with them (KOVÁCS-LÁNG and VERSEGHY 1974, VERSEGHY and KOVÁCS-LÁNG 1975).

In the course of his investigations SMITH (1962) pointed out that the lichens draw nitrogen compounds accessible from their environment relatively easily. In spite of it the incorporation of the drawn N compounds as well as the decomposition of the protein of the lichens is a rather slow process. According to him the low turnover rate of the protein is a general characteristic feature of the lichens, it is in connection with their slow growth and relatively long life time.

Turnover rate and time of the mineral substances have already been analyzed in a year relation in our previous work (KOVÁCS-LÁNG and VERSEGHY 1974, VERSEGHY and KOVÁCS-LÁNG 1975). In the present work, however, I would like to compare the turnover rate and time of the mineral substances with the turnover rate and time of the lichen phytomass, thus the turnover has been calculated in like manner as the phytomass, for months and winter- and summer-periods, respectively. On the basis of the results thus obtained the Ca turnover proved to be the quickest in the lichens while that of the nitrogen, the slowest (Table 5).

The turnover time of the elements studied in the total-lichens of the two communities is variable but the processes of mineral material exchange are uniformly slower in the summer (growing) period. Comparing the two winter periods to each other, the mineral material exchange was quicker in the winter of 1970–71 than in the winter of 1971–72, both in the individual species and total lichens of the perennial and annual grasslands. It can be established at the same time that the turnover of mineral substances is quicker

in the period of decomposition than in that of incorporation. The turnover time of mineral substances of the two predominating lichen species differs by associations. The turnover of the mineral substances of *Cladonia magyarica* is slower in the *Festucetum vaginatae* association than in the *Brometum* while, on the other hand, the turnover time of mineral substances of the *Cl. furcata* is slower in the *Brometum* and quicker in the *Festucetum vaginatae*, similarly to the turnover of the phytomass.

It can be unanimously found that the turnover rate of all the three elements (Ca, K, total-N) is greater in the perennial grassland (*Festucetum vaginatae*) than in the annual one (*Brometum*). Here, too, the direction of the processes is determined by weather factors, that is why the two winter periods differ from each other, with the same sign in both associations. In the growing period, however, the negative influence of the dry, hot summer can be felt less in the *Brometum*, e.g. in August an incorporation of all the three elements can be observed while a strong decomposition can be seen in the perennial grassland.

## Comparison of the turnover of phytomass with that of the mineral substances

Investigation of the phytomass of the grassland communities was started in the growing period of 1968 while investigations of mineral material exchange were not accomplished in this period. Consequently, the mineral material exchange can be compared only with one growing period, the summer of 1971.

The intensity of the turnover rate of the lichen phytomass and mineral substances is similar, i.e. it is greater in the perennial grassland and smaller in the *Brometum*. The direction of the processes, however, is not unanimously the same. The incorporation or decomposition cannot always be observed in the same month for the phytomass and mineral material exchange, respectively. E.g. the K, Ca and total-N contents of the lichens in the perennial grassland shows a decomposition of large extent in the January of 1971 and an incorporation in the system in February while the phytomass is decomposing in both months. The annual grassland shows a more uniform picture.

It can be established, however, that in the individual periods both the changes of the phytomass and the turnover rate of the mineral substances are generally influenced not by the seasons but by the changeable weather factors. The winter of 1970–71 was more rainy than that of 1971–72. On the other hand the winter of 1970–71 can be unanimously characterized by decomposition processes while the winter of 1971–72, by incorporation processes. The knowledge of the changes of the individual weather factors (Tables 6 and 7) helps to understand this contradiction. (In the vital functions of the lichens a

considerable role is generally attached to rainfall and humidity, respectively.) It can be seen from the data of the radiation minimum partly defining the time of vital functions of the lichens that the winter of 1970–71 was colder than that of 1971–72. The amounts of the total radiation, however, were higher in the winter of 1971–72. Thus, in winter, the decisive factor is not the arid or humid character of the season but the total radiation and the temperature.

The direction of the processes changes several times in the growing period, in the perennial *Festucetum* it is more intensive both in the phytomass change and exchange of mineral substances. In the droughty summer of 1971 the decomposing processes were predominating during the whole growing period while the balance of total productivity of the growing period

**Table 6**

*Daily changes of the climatic factors in the summer period of the studied*

| Year | | $t_2—t_1$ | *a* | *b* | *c* | *d* |
|---|---|---|---|---|---|---|
| 1968 | IV–V | 27 | 6.7 | 75.9 | 3.04 | 474 |
| | V–VI | 29 | 10.7 | 66.1 | 1.77 | 541 |
| | VI–VII | 32 | 10.4 | 59.9 | 1.28 | 584 |
| | VII–VIII | 39 | 11.1 | 81.1 | 2.19 | 412 |
| | VIII–IX | 13 | 12.5 | 83.5 | 0.97 | 364 |
| 1971 | IV–V | 35 | 4.9 | 72.7 | 1.67 | 445 |
| | V–VI | 42 | 10.1 | 73.8 | 1.54 | 558 |
| | VI–VII | 20 | 11.2 | 67.6 | 1.28 | 541 |
| | VII–VIII | 28 | 12.7 | 68.6 | 0.44 | 499 |
| | VIII–IX | 32 | 9.4 | 74.9 | 1.43 | 393 |
| 1972 | IV–VI | 58 | 8.7 | 83.3 | 2.48 | 434 |
| | VI–IX | 84 | 13.2 | 80.9 | 2.71 | 442 |

$$a = \frac{\text{years sum of radiation minimum}}{t_2 - t_1,}, \text{°C}$$

$$b = \frac{\text{amount of humidity measured at 7 o'clock}}{t_2 - t_1}, \%$$

$$c = \frac{\text{monthly rainfall amount in mm}}{t_2 - t_1}$$

$$d = \frac{\text{amount of total radiation}}{t_2 - t_1}, \text{gKcl/cm}^2$$

$t_2 - t_1$ = number of days between two measurements

of 1972 was positive. These results are in connection with the arid character of 1971 and with the humid character of 1972, respectively.

Studying the connections between the influence of the individual weather factors and the total productivity of the lichens it has been established (VERSEGHY 1976, 1977) that the order of importance of the environmental factors is quite different in the winter and in the summer months. From the analysis of the studied environmental factors it can be concluded that "other" factors, e.g. microclimatic influences not known in their full details sometimes play much more significant part than the macroclimatic ones.

Connections have been studied between the turnover time of the lichen phytomass and mineral substances. It can be stated that the turnover time of the lichen phytomass is much more longer than that of the mineral substances (Table 5). Studying the total-lichens of the two associations it can be seen that the turnover time of the substances is quicker two or three times, exceptionarily four to six times than that of the phytomass but the difference is extraordinarily apparent in case of the two predominating lichen species. The mineral turnover of the *Cladonia magyarica* living in the *Festucetum* and that of the *Cladonia furcata* living in the *Brometum* is six to eight times quicker than the phytomass turnover.

**Table 7**

*Daily changes of weather elements in the winter period of the years of investigation*

| Year | | Number of days ($t_2$—$t_1$) | *a* | *b* | *c* | *d* |
|---|---|---|---|---|---|---|
| 1970 | XI–XII | 17 | 1.1 | 95.9 | 0.45 | 65 |
| | XII–I | 42 | —6.9 | 95.6 | 2.32 | 61 |
| 1971 | I–II | 25 | —2.0 | 97.2 | 1.33 | 112 |
| | II–III | 32 | —4.6 | 93.0 | 0.51 | 170 |
| | III–IV | 25 | 3.1 | 87.1 | 0.75 | 311 |
| | IX–X | 26 | 3.1 | 88.3 | 0.96 | 303 |
| | X–XI | 28 | —1.5 | 90.2 | 0.43 | 176 |
| | XI–I | 64 | —1.2 | 93.4 | 1.09 | 57 |
| 1972 | I–II | 41 | —5.1 | 92.5 | 0.64 | 125 |
| | II–III | 30 | 0.9 | 87.6 | 0.48 | 238 |
| | III–IV | 28 | 3.5 | 87.6 | 0.87 | 352 |
| | IX–X | 37 | 5.1 | 89.2 | 1.10 | 243 |
| | X–XII | 62 | 0.7 | 88.3 | 0.91 | 108 |

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# VEGETATION DYNAMICS INDUCED BY SOME HERBICIDES IN A PERENNIAL GRASSLAND COMMUNITY, I

Klára Virágh

RESEARCH INSTITUTE FOR BOTANY, HUNGARIAN ACADEMY OF SCIENCES, VÁCRÁTÓT, HUNGARY

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This introductory publication demonstrates the planning and antecedents of such an experiment in which quick processes of vegetation dynamics are induced by selective herbicides to monocotyledons and dicotyledons (Gabonil, Dalapon) and by herbicides of different mechanisms and total effects.

The article analyses in detail the aims of the study programme. The investigations are aimed partly at the study of the structure changing in the course of secondary succession and degradation induced by the herbicide treatments and partly at the knowledge of the processes of vegetation dynamics induced outwardly and the mechanisms regulating these, as well as the regeneration capability of the community (*Pulsatillo-Festucetum rupicolae*).

## Introduction

### *On the vegetation dynamics: general problems*

Vegetation dynamics can be defined as, for example, "the study of changes in vegetation in time" — Miles (1978), or as "the change with time of a vector of some suitable measurements of plant species performance" — Austin (1981).

The study of vegetation dynamics includes the investigation of the successional trends, climatic changes and climatic fluctuations, cyclic changes and the persistent effects of episodic events or random noise.

Today it is very difficult to determine which of the effective components, e.g. the succession or the climatic fluctuation, is responsible for the observed vegetation changes. Fluctuational changes of certain extent, secondary successional processes or regeneration cycles take place simultaneously in all communities. All these changes are fundamentally similar processes, which result from the continuous flux in populations of individual species that make up the vegetation, and differ from one another mainly in the rate of time.

At present the terminology of vegetation dynamics is very confused in the ecological literature. In a wording successions can be termed as directional changes away from an initial state. During successional changes there are progressive or regressive alterations in the structure and species composition of the vegetation. In *cycling changes* similar vegetation types recur in the same place at various intervals of time. *Fluctuational changes* may be thought of as short term (changes from year to year, or over periods of a few years only) and generally reversible, when vegetation keeps the same overall composition in terms of the combination and proportions of the species present. Fluctuational changes in vegetation result e.g. from differences in the seasonal growth cycles of the component species (aspectional or phenological changes of the vegetation), and from biotic and climatic changes in the environment.

Separation of these changes is, in many cases, arbitrary and difficult. The processes of regeneration, for example, can not very often be distinguished from the secondary successions or fluctuational and cyclic changes, respectively. The mentioned processes of different type, however, must be taken into consideration by all means in the study of any nature of the vegetation dynamics.

Besides, it is also to be noted that the general basic principles of the certain processes of vegetation dynamics and mainly the moving forces of these have not been cleaned up till now.

Succession is one of the vegetation processes studied for the longest time past, the theory of which was born at the end of the last century. Since then several articles and summarizing works (Whittaker 1953, Knapp 1974, Golley 1977, Miles 1979, van der Maarel and Werger 1978, Austin 1981, Usher 1981) have been published on the succession but its theory is actively discussed even today. Details on the different succession theories are not given here, only a few basic problems gathered around two groups of questions are mentioned the solutions of which will lead to the clarification of the substantial questions of the succession.

## How does the succession take place?

Most ecologists (Clements 1916, Braun-Blanquet 1928, McArthur and Connell 1966, Whittaker 1953, 1970, Odum 1969, 1971) were convinced for decades that the succession is, starting from a very pristine, simple situation even without organisms or to be characterized by a few organisms, a regular series of progressive developmental stages. This process proceeds step by step towards a final, most organized, so called "climax" stage. Succession is a regular process, which is always unidirectional and predictable.

This theory of succession and its classic climax conception have recently been criticized by, among the others, Drury and Nisbet (1973), Colinvaux (1973), Horn (1974, 1976a) and Connell and Slatyer (1977). The discussed questions concerned mainly such important problems as, for example,

— if the convergence is absolutely acceptable in the successional development (Question of convergence-divergence)

— justness of climax conception

— question of stability

— ways of succession

alteration in communities (Clements 1916 and his followers)

plant-plant substitution (McArthur 1958, Anderson 1966)

frontal invasion (Glenn and Levin 1980)

— if the process of succession is a regular, uniform series of alteration in the populations or irregular change of those, which has no uniformity (Whittaker 1953) (deterministic-stochastic models)

— nature of the relationship between the community and the environment (Clements 1916, Whittaker 1953)

— if the succession is controlled by the ecosystem (Odum 1969, 1971) or rather by the population (Drury and Nisbet 1973)

— importance of the autogenous and allogeneous succession.

Today, according to the recent conceptions, it can be stated for example that the convergence has no general validity in the development of the vegetation. In the process of succession divergent, reticular ways also exist, which may produce not a final but several stages at the same time. Thus the development of the vegetation can not always be considered unidirectional and the direction of the changes can not be predicted.

## What directs the development of the succession?

Clements (1916) gave 6 subprocesses: initiation (physiographic, climatic, biotic processes); immigration of new species; ecosis; competition; site modification (reaction); stabilization of the climax, which are important in the development of the succession. Of these mainly the process of action-reaction was considered of decisive importance by him.

Egler's (1954) hypothesis of "initial floristic composition" meant a revolutionary change against Clement's (1916) "relay floristic" conception. Egler emphasized that the substitution of the species is not continuous, and all the species appearing in the course of succession can be found in the vegetation in the form of buried seed, propagulum, while the alteration of the vegetation types is the result of the increase in the seed bank of the soil, and of the different life cycles, differentiated growth of the species. This theory has become very popular and been applied much more widely than Egler himself imagined it (see, for example, Colinvaux 1973, Drury and Nisbet 1973, Horn 1974).

Of the recent theories, for example, Connell and Slatyer (1977) have worked out such models of successional processes (facilitation, tolerance, inhibition), which include both the relay floristic theory and that of the initial floristic composition, independently and combined with each other. This population theory has been developed by Noble and Slatyer (1980). According to them, in the process of the succession certain major species play an important role. And it is the life history which determines the predominating species in the individual successional stages.

It is still undecided if the decisive role of the "reaction" or rather that of the competition is important in the advance of the succession. But when studying the processes of vegetation dynamics, the possibility of almost all of the above-mentioned theories and moving forces of succession is to be faced.

It can shortly be stated that Clement's theory (1916) and a part of the later classic theories (Odum 1969, 1971; Margalef 1968; Lanford and Buell 1969; Whittaker 1970) are concerned with the whole community and ecosystem, respectively, as well as with the community and environment complex. The recent studies, however, emphasize the basic, essential role of the population dynamics, mainly of the population interactions (e.g. Drury and Nisbet 1973, Horn 1976), the ecological mechanisms, plant strategies regulating the succession of the population (Grime 1978) in the change of all the vegetation.

At present not only the theory of the succession and its approach on different levels (population, community, ecosystem) but also the quantitative methods suitable for describing the processes of the succession (Londo 1974, Beeftink 1979, van der Maarel and Werger 1978, van der Maarel 1979a, Knapp 1974, Austin 1981, van Leeuwen 1966, 1973) are under discussion.

Naturally, it is not enough to describe qualitatively the certain vegetation types (life-forms, growth forms, spreading types, sociological indicator values of species, taxonomical properties), to get acquainted only with their quantitative cenological features (cover-abundancy, frequency, density) and to analyze them comparatively, qualitative and half-quantitative evaluation re-surveyed every 10–20 years is not sufficient. Today, in the numerical approach of the succession investigations mainly the multivariate analyses (PCA, Association analysis, Reciprocal averaging, Canonical vectors, Canonical correlation, Cluster analysis) are predominating, which undoubtedly make the more exact interpretation of the vegetation changes possible (Williams et al. 1979, Orlóci 1978, van der Maarel 1979b, Helmecke 1975, Austin 1977). In the study of succession newer and newer, very promising methods are represented by the models of the different dynamic and stochastic processes (Londo 1974, Shugart et al. 1973, Horn 1974, 1976b, Hulst 1975, Usher 1981) by which also the solution of the questions of equilibrium and stability can be better approached. To under-

stand and at last to predict the process of succession long-termed (permanent plots) and detailed observations are needed by all means (BEEFTINK 1965, 1977; WESTHOFF 1969, AUSTIN 1981, LONDO 1974, 1975).

Basic shortcomings are constituted by our restricted knowledge related to the structure and the "pattern" basic phenomena (diversity, similarity, preference) practically not elaborated up to the present as well as the structural models based on their dynamic connections by which the changes taking place during the succession could be interpreted satisfactorily and the regularities, controlling mechanisms of the changes could be established (JUHÁSZ-NAGY 1979a). The exact knowledge of the structural changes and functional processes based on them as well as a more exact, thorough analysis of the course of "normal" succession are urgent necessities also because without these one can not efficiently go on and understand the regularities of the negative, "abnormal" succession, the degradation.

Degraded processes of such an extent as today, however, have never taken place. Due to the human influences degradation of the vegetation has become a world-problem graver than ever. In consequence of the cultivation of the forestry and agricultural areas, as well as of the human management (removal of weeds, application of chemicals and fertilizers) quick destabilization, degradation and often irreversible changes of the used natural systems can be observed. The drastic human effects (exterior degradation) entail consequences that are difficult to foresee, starting of quick degradation processes, but degradation of the stands, spreading of the unvaluable and noxious species can be observed also as a consequence of the unsuitable utilization (overgrazing, lack of regular mowing, erosion). Unfortunately, unrichness of species and homogeneity (interior degradation) moreover, total destruction of the natural and semi-natural communities have become a general phenomenon for the present.

At the present little is known about what takes place in a degradation process and what defects of the supraindividual organization are linked with the different types of degradation (JUHÁSZ-NAGY 1979b). Moreover, even the methods suitable to follow up the phenomena of degradation are hardly in possession of us.

On the basis of all these a profound knowledge of the already mentioned successional processes as well as the secondary succession and degradation processes caused by some perturbation becomes an urgent task.

## Experimental approach of the vegetation dynamics

In a community the successional and degradation processes take place simultaneously and by turns.

The study of these and other processes of vegetation dynamics as well as their ecological backgrounds is, due to its time consuming feature, very circumstantial. For this reason, and as there is also relatively little possibility to study the secondary succession and primary succession, methodologically the application of experimental techniques seems to be very promising. As the selective removal of the individual species-groups or the total destruction of the vegetation results in quick processes of vegetation dynamics.

The mechanism of the organization of the communities, the changes of the relations between the populations were studied mainly by the mechanical removal of the dominant species, by DAYTON (1975), PINDER (1975), ALLEN and FORMAN (1976), ABUL-FATIH and BAZZAZ (1979). Experimental ecological investigations of such nature have been carried out by applying selective herbicides first by SUGAR and HARPER (1961), PUTWAIN and HARPER (1970) and then e.g. FOWLER (1981). MAHN and HELMECKE (1979) followed up the structural changes in a community, taking place under the influence of the herbicide treatment.

## The programme of our investigations

In 1979 we began an experimental programme in a semi-natural grassland community rich in species, where selective herbicides and those of total effect were applied in order to study the processes of the secondary succession and degradation, the mechanism regulating these as well as the regeneration capabilities of the community and the sources of the regeneration.

Removal of certain groups of species by selective herbicides made possible the simplification of the vegetation and the relationships between the species and thus the better understanding of the basic phenomena, on a more simplified object of investigation. By the application of the herbicides of total effect, however, processes of vegetation dynamics accelerated artificially could be studied. The herbicides exert an influence on several level (e.g. population, community) of the supraindividual organization. They induce several changes in structure and function, processes of vegetation dynamics of different direction, for the study of which there is also investigational possibility of different level and depth. Consequently, in order to realize our objectives, our partial problems of study were designed in more steps and our questions were intended to answer mainly through the changes in the structure.

## Investigation of the community before the perturbation

Study of the connections prevailing in the original "natural" grassland community the *structure*

(species composition
pattern regularities, analysis of spatial processes
diversity
interspecific correlations

partition of niche space
"coexistent" structures)
and *the function* (biomass) of the community.

## Investigation of the community after the perturbation

*I. Study of the organization of the community and the extent and direction of the structural changes taking place due to the removal of the dominant (monocotyledonous species) and less dominant (dicotyledonous species) groups of species from the sward by herbicides:*

— how do the structure of the vegetation and the organization of the community change after the perturbation and how do the changes depend on the different doses of the herbicides;

— how do the connections between the species, species-groups influence the organization of the community and its change in time.

— Resistance of the community against perturbation

Will the original structure be re-established after the herbicide-treatment ?

If it will, in how much time ?

If it will not, whether a newer condition of equilibrium will form or changes of retrogressive direction will take place.

What relation will the community structure (diversity, niche structure) have to the stability ?

What is the extent of destruction and regeneration of the vegetation with the different doses of the herbicides applied.

— Study of the occurring degradation phenomena and their reasons, as well as their description according to the different degradation stages of the community.

*II. Total destruction of the vegetation by herbicides of different mechanisms and total effect and study of the secondary succession and degradation following the destruction:*

— What is the role of

the species richness of the local flora, the vegetation of the surrounding area, the different intensity and doses of the herbicide treatments and the potential seed bank of the soil in the course of secondary succession ?

— What is the species composition of the communities appearing after the herbicide treatments and how are they changing during the years.

— What model will satisfactorily describe the changes of species composition and the substitutions between the groups of species.

— What is the distribution of the populations like in the different stages and what is it in the stable state ?

— How much time is required for the stable state ?

— What is the source of the regeneration after the several herbicide treatments:

vegetative regeneration,

seasonal regeneration (e.g. autumn regeneration after the spraying in June),

mobilization of the seed contents of the soil.

*III. Experimental study of the primary succession on sterilized soil.*

*IV.1. Study of the effect of the nitrogenous fertilization.* What qualitative (species composition) and quantitative (biomass) changes are caused by the fertilization.

*IV.2. Results of the simultaneous application of a selective herbicide and the fertilization.*

## Theory and practice

The programme of this investigation is mostly a theoretical, basic study according to its objects. In the planned series of investigations it was designated as a principal task to look for and apply such structure models based on phytosociological data, which are suitable for the description and interpretation of the vegetation changes of different direction. Besides, our aim is to interpret the complicated changes, processes of succession and degradation on the level of such basic phenomena as for example the diversity, similarities, interspecific relations as well as by the expedient application of the multivariate analyses (PCA, FKI = Factor Continuum Index, Association Analysis, Cluster Analyses). It is our plan to try to make the Markovian chains theory to be an applicable method also in the grassland communities in order to evaluate the distribution of the populations in the several stages of the succession and predict the occurrence of the stable state.

These are mainly problems of theory and methodology but our problems described in detail and our basic questions of the investigation are, almost without exception, such ones which are closely connected to the agricultural problems and the solution of which can be directly utilized in the practice, in the sward farming.

By the herbicides applied in the usual method for removal of the weeds and by the fertilization serving for the improvement of the swards the same

shiftings in structure and damages are produced in the grassland community by the agriculturalists, range management workers, as the ones we are investigating in our experiments. Such questions, important for the practice, as for example:

— how can a composition, advantageous for economy, (community free of weeds, an advantageous ratio of the useful and unuseful species from the point of the yield) be maintained;

— what is the extent of the rate of destruction and regeneration with different doses of the different herbicides;

— which are the optimal doses and when, with what dose application will the pernicious changes (unfavourable also economically), irreversible degradative processes take place;

— what is the resistence of the community like against a drastic external effect, can not be answered without the knowledge of the vegetation dynamics, regularities of the "replacement" population, balance population magnitudes and circumstances of stability (FEKETE and VIRÁGH 1982).

So the aim of our investigations was to provide, through an analysis on the structure of the original undamaged community and that of the community influenced by herbicide and fertilizer treatments and on the ecological background of the changes as well as through the study of the processes of vegetation dynamics, such reliable basic data, such knowledge for the practice, which make advantageous agrotechnical interventions and surveying of their probable consequences possible.

Sward-farming altered radically in the last decades can not already do without the application of the herbicides and fertilizers. At the present the grassland of 1.3 mill. ha means a reserve with great potential energy for the agriculture of our country, a reserve which is not yet suitably utilized at the present. The investigations carried out up till now show that some 30% of this great area is strongly weedy, and hence it requires improvement, modern sward-farming by all means.

At the present our knowledge is far behind the demands of the agriculture, thus it is indispensable necessity to develop quickly our theoretical and methodological knowledge and to widen the studies similar to our experiments.

## Short characterization of the experimental area and its environs

Our experiments were set on a dry-situated hill, on the widening part of the valley of the Tard stream falling on the foreground of the Bükk, at the Southern foot of the Bükk Mountains (NE Hungary).*

* Some agricultural experts have already worked on the more degraded part of this area (SZEMÁN 1979), so our investigations already have preliminaries.

## Geology

The Southern foots of the limestone mountains of the Bükk are composed, in a height of 200–300 ms, of rhyolite tuff, andesite tuff and dacite tuff. This gentle hilly country becomes lower and lower in the Southern direction and turns into the foreground of the Bükk near the village of Tard.

The foreground of the Bükk is a large alluvial cone formed during Pliocene and Pleistocene, which was formed by the brooks streaming down from the Bükk. The layers of the Pannon sea can be found under the alluvial cone.

Loess is the soil forming rock on the studied area.

## Climate

The climate of the valley of the Tard stream occupies an intermediate position between that of the Great Hungarian Plain and the mountainous district. The mean annual temperature is 9 °C, the total moisture at Tard is about 600 mms (on the basis of a 50 year average).

## Soil conditions

The soil is brown forest soil of chernozem character, formed on loess.

The humous level "A" is of dark brown, black colour, 40 cms thick, of acid reaction, well supplied with nitrogen but poor in phosphorus. The level "B" of accumulation is of red-brown and of slightly acid reaction. Its total nitrogen and phosphorus contents are very low. Of the exchangeable cathions Ca is predominant.

The individual layers of the soil segment are shown in Fig. 1 while the detailed results of soil investigation, in Table 1.

It is to be noted that on our experimental area, in many places, the "B" level of transition and accumulation, which is already very poor in humus, rose to the surface due to the soil erosion.

## Vegetation*

The foreground of the Bükk Mountains is an independent flora region of the name of Borsodence of the flora country of the Northern Hungarian Uplands. It is situated on the boundary of the Matricum and Pannonicum. Up till now two works, to be considered relatively detailed, have been published on its floristic conditions (Tóth 1963, 1973).

The area, on which our experiment was set, is a secondary steppe community (*Pulsatillo-Festucetum rupicolae*) formed in the place of a deforestation, which can be considered as a closing community in the successional series of the perennial grasslands in the given area.

Due to the anthropogen effects, intensive grazing, trampling the *Festuca pseudovina* type of the association, considerably tainted also with weeds, occurs in the environment. Besides, agriculturally cultivated areas, plough-lands and orchards can also be found in the environs.

In the place of the species-rich steppes utilized today mainly as grazing-lands, on the presumed brown forest soil formed on the loess basic-rock once the zonal forest of the lowland loess ridges, the closing plant community of the series of loess succession, the loess-land

* As to the nomenclature of the species Soó's work (1980) (Volume VI) was followed by us.

**Table 1**

*Data of investigation of the brown forest-soil of chernozem*

| Sampling (cm) | 0–10 | 10–20 | 20–40 | 40–50 | 50–70 | 70–90 | 90–100 |
|---|---|---|---|---|---|---|---|
| Basic data | | | | | | | |
| ph in $H_2O$ | 5.2 | 5.5 | 5.7 | 5.8 | 6.0 | 5.9 | 5.7 |
| in nKCl | 5.0 | 5.4 | 5.5 | 5.4 | 5.3 | 5.1 | 4.9 |
| hy | 2.04 | 1.78 | 1.60 | 1.63 | 1.79 | 1.94 | 2.44 |
| Humus, % | 4.85 | 3.09 | 1.23 | 0.46 | 0.36 | 0.30 | 0.20 |
| Fe, me/100 g | 300 | 282 | 170 | 140 | 114 | 70 | 65 |
| Mn, me/100 g | 400 | 388 | 282 | 188 | 80 | 10 | 9 |
| Total N% | 0.26 | 0.19 | 0.10 | 0.06 | 0.05 | 0.05 | 0.04 |
| Total P% | 0.050 | 0.030 | 0.020 | 0.020 | 0.017 | 0.013 | 0.013 |
| Exchangeable cathions | | | | | | | |
| Ca, me/100 g | 16.00 | 15.20 | 12.00 | 11.20 | 11.30 | 11.80 | 13.40 |
| Mg, me/100 g | 0.22 | 0.19 | 0.17 | 0.22 | 0.22 | 0.30 | 0.35 |
| K, me/100 g | 0.35 | 0.28 | 0.30 | 0.27 | 0.30 | 0.27 | 0.28 |
| Na, me/100 g | 0.32 | 0.36 | 0.56 | 0.31 | 0.38 | 0.44 | 0.63 |
| S | 16.89 | 16.03 | 13.03 | 12.00 | 12.20 | 12.81 | 14.66 |
| T | 23.00 | 19.50 | 15.50 | 14.00 | 14.00 | 15.00 | 20.50 |
| Ca, S% | 94.70 | 94.79 | 92.06 | 93.29 | 92.59 | 92.12 | 91.41 |
| Mg, S% | 1.33 | 1.22 | 1.34 | 1.87 | 1.84 | 2.34 | 2.39 |
| K, S% | 2.07 | 1.75 | 2.30 | 2.25 | 2.46 | 2.11 | 1.91 |
| Na, S% | 1.89 | 2.25 | 4.30 | 2.58 | 3.11 | 3.43 | 4.30 |
| V% | 72.13 | 82.23 | 84.10 | 85.75 | 87.18 | 85.40 | 71.51 |

oak-forest with tatare maples, the *Aceri-tatarico-Quercetum* could be found. The characteristic species of this e.g. the *Quercus pubescens*, *Acer tataricum*, *Nepeta pannonica* and *Phlomis tuberosa* can be found in smaller areas, in the smaller forest-remains, tree-groups near our sample area even today.

The investigated grassland community is rich in species, consists of 80 to 100 species, and is less weedy. The reason of the richness in flora lies in that the area is situated on the confines of the Plain, near the Bükk Mountains as well as in its varied geological structure. Accordingly, the continental steppe-species as for example the *Stipa capillata*, *Echium russicum*, *Euphrasia tatarica*, *Pulsatilla nigricans*, *Pulsatilla zimmermannii*, *Koeleria cristata*, the subendemic *Dianthus pontederae* and *Thlaspi jankae*, the continental forest-steppe elements as for example the *Asparagus officinalis*, *Brachypodium pinnatum*, *Iris variegata*, *Arenaria graminifolia*, as well as the subatlantic *Genista tinctoria*, and the acid soil indicating *Viscaria vulgaris* and *Luzula campestris* can be found together in the stand. Of the characteristic species of the woolly-grass communities of the Bükk plateau the *Danthonia decumbens* can be found. In the area, the *Danthonia alpina* and *Leontodon hispidus* are cleared grass-land elements

*character, formed on loess (Tard) (April, 1981)*

| 100–120 | 120–130 | 130–145 | 145–155 | 155–160 | 160–165 | 165–170 | 170–180 | 180–185 | 185–220 |
|---|---|---|---|---|---|---|---|---|---|
| 5.9 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.2 | 6.2 | 6.2 |
| 5.2 | 5.4 | 5.4 | 5.2 | 3.3 | 5.4 | 5.4 | 5.2 | 5.2 | 5.2 |
| 1.54 | 1.58 | 1.92 | 1.55 | 1.83 | 1.22 | 1.95 | 1.41 | 2.04 | 1.20 |
| 0.15 | 0.05 | 0.20 | — | 0.15 | — | — | — | 0.12 | — |
| 28 | 41 | 58 | 28 | 45 | 41 | 58 | 39 | 65 | 22 |
| 11 | 20 | 18 | 8 | 6 | 92 | 26 | 60 | 42 | 13 |
| 0.04 | 0.04 | 0.035 | 0.04 | 0.04 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 0.009 | 0.013 | 0.017 | 0.013 | 0.017 | 0.009 | 0.017 | 0.013 | 0.017 | 0.009 |
| 9.00 | 10.00 | 12.20 | 10.40 | 11.80 | 7.40 | 11.60 | 10.50 | 12.80 | 8.40 |
| 0.27 | 0.25 | 0.35 | 0.25 | 0.30 | 0.17 | 0.22 | 0.17 | 0.27 | 0.10 |
| 0.25 | 0.22 | 0.18 | 0.15 | 0.24 | 0.17 | 0.25 | 0.10 | 0.25 | 0.12 |
| 0.45 | 0.56 | 0.70 | 0.63 | 0.65 | 0.45 | 0.68 | 0.68 | 0.72 | 0.28 |
| 9.97 | 11.03 | 13.43 | 11.43 | 12.99 | 8.20 | 12.75 | 11.45 | 14.04 | 8.90 |
| 13.00 | 13.50 | 18.50 | 13.50 | 16.00 | 10.10 | 16.00 | 12.50 | 16.00 | 11.00 |
| 90.23 | 90.62 | 90.84 | 90.99 | 90.24 | 90.84 | 90.94 | 91.66 | 91.14 | 94.38 |
| 2.76 | 2.27 | 2.61 | 2.19 | 2.31 | 2.13 | 1.76 | 1.53 | 1.96 | 1.12 |
| 2.51 | 2.04 | 1.34 | 1.31 | 1.85 | 2.13 | 1.96 | 0.87 | 1.78 | 1.35 |
| 4.51 | 5.07 | 5.21 | 5.51 | 5.00 | 5.49 | 5.33 | 5.33 | 5.13 | 3.15 |
| 76.73 | 81.74 | 72.59 | 84.67 | 81.19 | 81.19 | 79.72 | 91.64 | 87.78 | 80.91 |

while ruderal species are, among the others, the *Plantago lanceolata*, *Plantago media* and the *Euphorbia cyparissias*.

Dominant monocotyledonous species constituting the community are the *Anthoxanthum odoratum*, *Agrostis canina* and *Festuca rupicola*. The most abundant dicotyledonous species are as follows: *Achillea collina*, *Genista tinctoria*, *Thymus marschallianus*, *Hieracium pilosella*, *Potentilla arenaria*, *Leontodon hispidus*.

The sward community, like generally the grass-lands and grazing lands, is characterized by the micro-heterogeneity, mosaic-complex-like dispersion of the species and quick aspect changes. In the wet early-spring period first the *Pulsatilla nigricans* and *Pulsatilla zimmermannii*, the *Carex caryophyllea* and *Luzula campestris* are in flower in the stand. In May the vegetation is dominated one after other by the *Orchis morio* and *Euphorbia cyparissias* flowering in large numbers; *Saxifraga bulbifera*; *Anthoxanthum odoratum*, then by the *Ajuga genevensis*. In June, the *Genista tinctoria* and *Thymus marschallianus*; the *Viscaria vulgaris* are in flower one after the other, and almost simultaneously the grasses as the *Festuca rupicola*, *Festuca pseudovina*, *Briza media*, *Koeleria cristata*, *Agrostis canina* and *Danthonia alpina*,
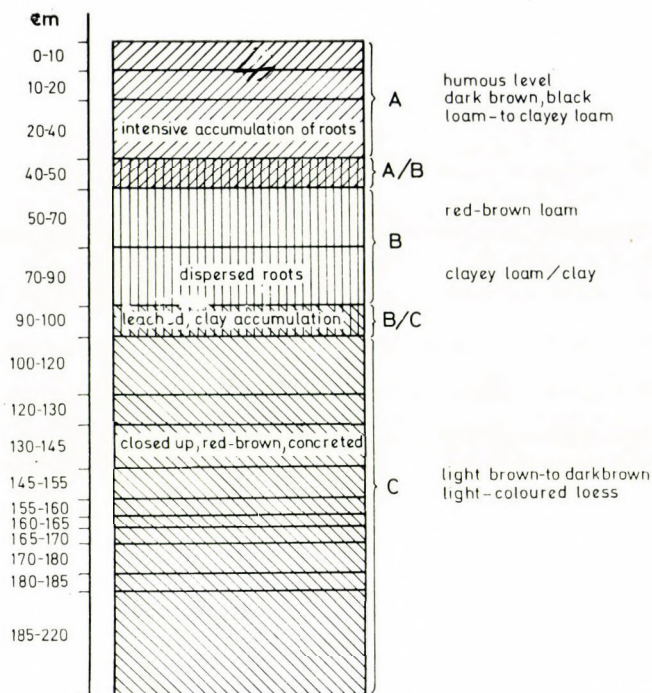
*Fig. 1.* Profile of the brown forest soil of chernozem character

then the *Salvia pratensis*, *Filipendula vulgaris*, *Hypericum perforatum* and *Leontodon hispidus*, which determine the early-summer aspect of the community. This is followed by a definite period of rest. After this dry, warm July, poor in flowers, the autumn aspect is characterized by the flowering composites, the *Carlina vulgaris*, *Centaurea pannonica*, *Inula britannica*, *Scabiosa ochroleuca* and umbellates, the *Pimpinella saxifraga*, *Daucus carota* as well as, of the grasses by the flowering *Bothriochloa ischaemum*. In September, the grass becomes green again, and the winter annuals, rosette annual Dicotyledons and a great part of the grasses start up.

The complete species list of the sample area with the indication of the Raunkiaer life-forms is given in Table 2. The species which could not be found in our quadrats marked out and surveyed in detail are indicated by x. The indicated frequency percentage was calculated on the basis of the presence of the species, in 1250 squares of $20 \times 20$ cms. This value characterizes the "original" state in June of the community, before spraying.

**Table 2**

*List of species*

| Name of species | Life-form | Family | Frequency, % |
|---|---|---|---|
| Gramineae | | | |
| *Agrostis canina* | H | Gra | 65.84 |
| *Agropyron repens** | H | Gra | |
| *Alopecurus pratensis** | H | Gra | |
| *Anthoxanthum odoratum* | H | Gra | 43.96 |
| *Bothriochloa ischaemum* | H | Gra | 34.32 |
| *Brachypodium pinnatum** | H | Gra | |
| *Briza media* | H | Gra | 5.52 |
| *Bromus mollis* | Th | Gra | 2.40 |
| *Calamagrostis epigeios** | H | Gra | |
| *Chrysopogon gryllus* | H | Gra | 8.96 |
| *Danthonia alpina* | H | Gra | 11.44 |
| *Danthonia decumbens* | H | Gra | 5.92 |
| *Festuca rupicola* | H | Gra | 81.28 |
| *Festuca pseudovina* | H | Gra | |
| *Helictotrichon pubescens** | H | Gra | |
| *Helictotrichon pratense* var. *subdecurrens** | H | Gra | |
| *Koeleria cristata* | H | Gra | 6.64 |
| *Lolium perenne** | H | Gra | |
| *Poa bulbosa** | H | Gra | |
| *Poa angustifolia** | G | Gra | |
| *Poa pratensis* | G | Gra | |
| *Phleum phleoides* | H | Gra | |
| *Setaria viridis* | Th | Gra | |
| *Stipa capillata* | H | Gra | 0.24 |
| *Stipa tirsa** | H | Gra | |
| Other Monocotyledons | | | |
| *Anthericum ramosum* | G | Lil | 1.68 |
| *Asparagus officinalis* | G | Lil | 0.40 |
| *Carex caryophyllea* | G | Cyp | 46.00 |
| *Iris variegata** | G | Iri | |
| *Luzula campestris* | H | Cyp | 66.64 |
| *Muscari comosum** | G | Lil | |
| Dicotyledons | | | |
| *Achillea collina* | H | Com | 87.12 |
| *Achillea nobilis* ssp. *neilreichii** | H | Com | |
| *Adonis vernalis** | H | Ran | |
| *Agrimonia eupatoria** | H | Ran | |
| *Ajuga genevensis* | H | Lab | 2.80 |
| *Anagallis arvensis* | Th | Pri | |
| *Anthemis tinctoria** | H | Com | |
| *Arenaria serpyllifolia* | Th | Car | 0.16 |
| *Arenaria graminifolia* | H | Car | 0.14 |
| *Asperula cynanchica* | H | Rub | 14.48 |
| *Astragalus glycyphyllos** | H | Fab | |
| *Betonica officinalis** | H | Lab | |
| *Campanula rotundifolia* | H | Cam | 0.16 |
| *Carduus acanthoides** | Th | Com | |
| *Carlina vulgaris* | Th-H | Com | 29.04 |
| *Centaurea pannonica* | H | Com | 5.44 |
| *Centaurium erythraea* | Th | Gen | 1.92 |

*Table 2* (continued)

| Nane of species | Life-form | Family | Frequency, % |
|---|---|---|---|
| *Cerastium brachypetalum* | Th | Car | 8.88 |
| *Cerastium semidecandrum* | Th | Car | |
| *Cerastium pumilum* | Th | Car | |
| *Chenopodium album* | Th | Che | |
| *Chondrilla juncea* | H | Com | 0.16 |
| *Convolvulus arvensis* | H | Con | 1.04 |
| *Crataegus monogyna* | M | Ros | 0.24 |
| *Daucus carota* | Th | Umb | |
| *Dianthus pontederae* | H | Car | 19.28 |
| *Dianthus carthusianorum** | H | Car | |
| *Dorycnium herbaceum* | H-Ch | Fab | 1.12 |
| *Echium russicum** | Th | Bor | |
| *Echium vulgare* | Th | Bor | 0.32 |
| *Erigeron canadensis* | Th | Com | 0.16 |
| *Erigeron acris** | Th-H | Com | |
| *Eryngium campestre* | H | Umb | 12.80 |
| *Euphorbia cyparissias* | H | Eup | 35.04 |
| *Euphorbia virgata** | H | Eup | |
| *Euphrasia tatarica* | Th | Scr | 30.00 |
| *Falcaria vulgaris** | Th-TH | Umb | |
| *Filipendula vulgaris* | H | Ros | 15.44 |
| *Fragaria viridis* | H | Ros | 10.16 |
| *Galium verum* | H | Rub | 1.28 |
| *Genista tinctoria* | Ch-N | Fab | 33.76 |
| *Gypsophila muralis* | Th | Car | |
| *Helianthemum ovatum** | H-Ch | Cis | |
| *Hesperis tristis** | H | Cru | |
| *Hieracium pilosella* | H | Com | 29.68 |
| *Hieracium bauhinii* | H | Com | 14.64 |
| *Hypericum perforatum* | H | Hyp | 17.92 |
| *Inula hirta* | H | Com | |
| *Inula britannica* | H | Com | 2.00 |
| *Knautia arvensis** | H | Dip | |
| *Leontodon hispidus* | H | Com | 50.00 |
| *Leucanthemum vulgare* | H | Com | 0.88 |
| *Linum catharticum* | Th | Lin | |
| *Lotus corniculatus* | H | Fab | 0.80 |
| *Medicago falcata** | H | Fab | |
| *Myosotis stricta* | Th | Bor | 1.12 |
| *Ononis spinosa* | H | Fab | 0.32 |
| *Onopordum acanthium** | Th | Com | |
| *Orchis morio* | G | Orc | 0.96 |
| *Peucedanum oreoselinum** | H | Umb | |
| *Pimpinella saxifraga* | H | Umb | 7.36 |
| *Plantago lanceolata* | H | Pla | 29.04 |
| *Plantago media* | H | Pla | 2.32 |
| *Plantago media* ssp. *stepposa* | H | Pla | |
| *Polygala comosa* | H | Pol | 2.40 |
| *Potentilla arenaria* | H | Ros | 42.56 |
| *Potentilla argentea* | H | Ros | 2.40 |
| *Pulsatilla nigricans* | H | Ran | 14.00 |
| *Pulsatilla zimmermannii* | H | Ran | |
| *Prunella laciniata* | H | Lab | 2.40 |
| *Prunus spinosa* | M | Ros | 0.16 |
| *Ranunculus polyanthemos** | H | Ran | |
| *Rhinanthus minor** | Th | Rhi | |
| *Rosa canina* | M | Ros | 0.16 |

*Table 2* (continued)

| Name of species | Life-form | Family | Frequency, % |
|---|---|---|---|
| *Rosa gallica** | M | Ros | |
| *Rumex acetosella* | H | Pol | 32.64 |
| *Rumex thyrsiflorus* | H | Pol | 0.72 |
| *Salvia nemorosa** | H | Lab | |
| *Salvia pratensis* | H | Lab | 1.12 |
| *Saxifraga bulbifera* | H | Sax | 7.20 |
| *Scabiosa ochroleuca* | H | Dip | 14.48 |
| *Scleranthus annuus* | Th | Car | |
| *Scorzonera purpurea** | H | Com | |
| *Senecio jakobaea* | H | Com | 0.32 |
| *Seseli annuum* | Th-H | Umb | 24.72 |
| *Seseli osseum** | H | Umb | |
| *Seseli varium** | H | Umb | |
| *Silene otites* | H | Car | 5.52 |
| *Silene parviflora** | H | Car | |
| *Silene pseudotites* | H | Car | 1.10 |
| *Solidago virga-aurea** | H | Com | |
| *Stellaria graminea* | H | Car | 2.24 |
| *Stellaria media* | Th | Car | |
| *Taraxacum officinalis* | H | Com | 1.44 |
| *Teucrium chamaedrys* | H | Lab | 9.44 |
| *Thalictrum lucidum** | H | Ran | |
| *Thalictrum minus** | H | Ran | |
| *Thesium ramosum* | H | San | 1.84 |
| *Thlaspi jankae* | H | Cru | 0.32 |
| *Thymus marschallianus* | Th | Lab | 92.72 |
| *Trifolium alpestre* | H | Fab | 2.72 |
| *Trifolium arvense* | Th | Fab | |
| *Trifolium campestre* | Th-TH | Fab | 0.24 |
| *Trifolium pratense* | H | Fab | 2.24 |
| *Trifolium montanum* | H | Fab | 1.28 |
| *Trifolium ochroleucum* | H | Fab | 0.28 |
| *Trifolium repens** | H | Fab | |
| *Verbascum phoeniceum* | H | Scr | 4.72 |
| *Veronica dentata* | H | Scr | 2.48 |
| *Veronica hederaefolia* | Th | Scr | 0.16 |
| *Veronica orchidea* | H | Scr | |
| *Veronica serpyllifolia* | H | Scr | 3.12 |
| *Veronica spicata* | H | Scr | 9.66 |
| *Vicia tetrasperma** | Th | Fab | |
| *Vicia cassubica** | H | Fab | |
| *Viola arenaria* | H | Vio | 5.60 |
| *Viscaria vulgaris* | H | Car | 13.52 |
| Lichens | | | |
| *Cladonia furcata* | | | |
| *Cladonia rangiferina* | | | |
| Mosses | | | |
| *Hypnum cupressiforme* | | | |
| *Polytrichum* sp. | | | |

## Design of the experiment, building up of the study area

Our investigations were started in 1979. The area of $40 \times 30$ ms marked out for the experimental purpose was enclosed then, and it has not been used as a pasture since that time.

In choosing the area it was a standpoint to choose a less degraded, species-rich, relatively homogenous stand for our ecological investigations. A larger continuous area of the community of *Festuca rupicola* type, which, probably due to the presence in great numbers of the Pulsatilla species, was almost entirely avoided by the animals, thus grazing did not cause degradation, seemed to be suitable for our purpose.

In the area 55 permanent quadrats were marked out. These were necessary by all means in our investigations partly due to the small area and the applied different treatments, partly because with random quadrats only the average changes could have been determined while with the permanent quadrats the spatial and temporal changes could also be followed well.

Our experiments were designed in a block-like arrangement (see Fig. 2), taking the microheterogeneity of the area into consideration. The experimental sites were divided into five replicate blocks and within each block 7–8
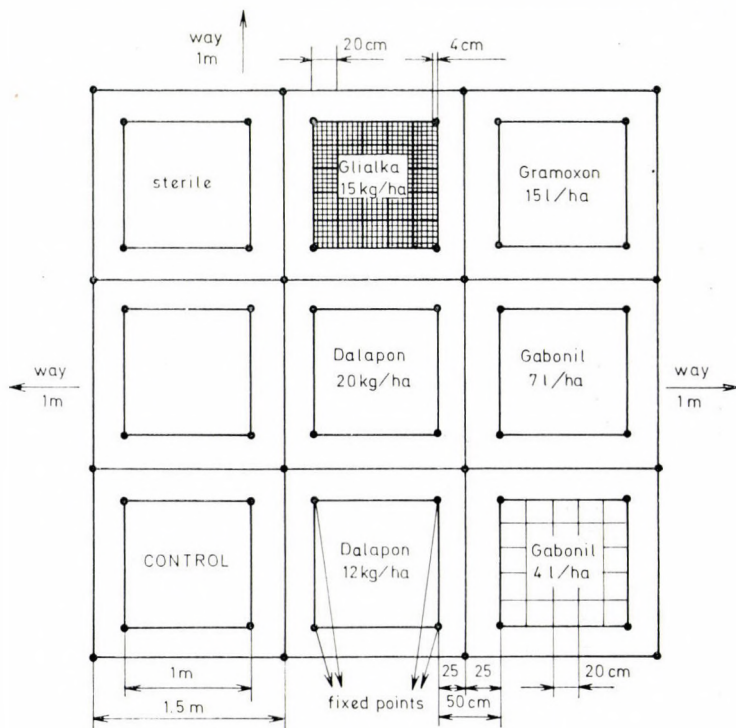
*Fig. 2.* Experiment design (one of the 10 blocks)

types of chemical treatment were applied to the sward. The treated quadrats are of 1.5×1.5 ms. The detailed investigations were carried out in permanent quadrats of 1×1 m by means of an iron-frame covered with a network in every 20 cms. Thus between each plot there was a puffer zone of 50 cms, which was treated but not recorded. The value of coverage of the species was estimated in contiguous quadrats of 20×20 cms in each case, except a herbicide of total effect where the quadrat was of 4×4 cms (Glialka see later), always two times annually, in June (before the sprayings) and in September.

Simultaneously with the recordings, samples were taken for the production investigations for 3 years (by monolith sampler of 20×20×10 cms). The samples were separated into species and within them into fractions (above-ground living plant parts, above-ground dead plant parts and under-ground plant parts). Weight measurements were carried out after a drying on 105 °C.

In October of every year a sample was taken from a soil depth of 8.5 cms, from the untreated (control), sterilized quadrats and from those treated by herbicides in order to determine the potential seed bank of the soil. (Sterilization of the soil digged out from 40 cms depth was carried out in an autoclave.)

Of the herbicides, selective for the Monocotyledons and Dicotyledons applied in the experiment the Dicotyledons were removed from the community by Gabonil, while the Monocotyledons by Dalapon.

To destroy all the vegetation 2 different non-selective herbicides of total effect were used. Sprayed once, the Gramoxon kills only the above-ground plant parts, and damages the roots and rhizomes only to a small extent while the seeds in the soil not at all. The other herbicide, the Glialka results in a much more stronger effect in the vegetation. It damages the seed bank of the soil neither, but completely kills the under-ground plant parts.

Sprayings were carried out at the end of June, 1979. The 2 herbicides of total effect were applied in a dose used and considered optimal in the sward farming, while the 2 selective herbicides in a dose under and above the optimum. In case of the selective herbicides of larger dose the treatments were repeated again after a year. 5 quadrats were not treated and studied as "control" also two times annually. The times of the sprayings and recordings, the chemical composition, doses applied and action mechanism of the herbicides are shown in Table 3.

For our experiments carried out with fertilizer, newer 5 blocks were marked out, in which 10 quadrats of 1.5×1.5 ms were treated by Gabonil at a dose of 7 l/ha in June of 1980, then in winter of 1981 of these quadrats 5 as well as 5 newer ones were fertilized by $NH_4NO_3$ in a fertilizer dose of 4.4 kg/100 m$^2$. Thus the effect of the pure fertilizer and the common effect of the herbicide and fertilizer have been studied since 1981.

The results of our studies started in 1979 will be published later.

**Table 3**

*Chemical treatments*

| Common name | Chemical name | Dose applied | Dates of treatments |
|---|---|---|---|
| Gabonil | MCPA + dicamba<br>4-chloro-2-methyl phenoxy-acetic acid + 2-methoxy-3.6-dichlorobenzoic acid | 4 l/ha in 500 l/ha $H_2O$<br>7 l/ha in 500 l/ha $H_2O$ | 27 June 1979<br>27 June 1979<br>26 June 1980 |
| Dalapon | 2.2-dichloropropionic acid | 12 kg/ha in 500 l/ha $H_2O$<br>20 kg/ha in 500 l/ha $H_2O$ | 27 June 1979 |
| Gramoxon | paraquat dichloride<br>1.1-dimethyl-4.4-bipyridy-lium dichloride | 15 l/ha in 500 l/ha $H_2O$ | 27 June 1979 |
| Glialka | glyphosate<br>N-(phosphonomethyl)glycine | 15 l/ha in 500 l/ha $H_2O$ | 26 June 1980 |

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*of the sward*

| Dates of recording | Type of action of herbicides |
|---|---|
| June 1979 | Selective leaf-herbicide of antiauxin type |
| Sept. 1979 | |
| June 1980 | It expels the indolacetic acid from the biochemical processes |
| Sept. 1980 | |
| June 1981 | It induces irregular cell-division, abnormalities in growth, metabolic |
| Sept. 1981 | troubles |
| June 1979 | Selective leaf-herbicide of auxin type |
| Sept. 1979 | It plays a role in the utilization of the energy, it exerts an influence on |
| June 1980 | the lipid metabolism |
| Sept. 1980 | Furthermore, it affects nitrogen metabolism, facilitates the degradation |
| June 1981 | of protein to amino acids and increases the level of amids |
| Sept. 1981 | It inhibits the synthesis of panthothenate stimulating the growth |
| 26 June 1979 | Leaf-herbicides exerting an effect on the Monocotyledons and Di- |
| 26 July 1979 | cotyledons |
| 7 Aug. 1979 | |
| 21 Aug. 1979 | |
| 7 Sept. 1979 | It inhibits the chlorophyll synthesis |
| June 1980 | |
| Sept. 1980 | |
| June 1981 | |
| Sept. 1981 | |
| June 1980 | Leaf-herbicide having an effect on the Monocotyledons and Dicotyledons |
| Sept. 1980 | |
| June 1981 | It inhibits the aromatic amino-acid synthesis |
| Sept. 1981 | |

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# BOOK REVIEWS

Editor: G. FEKETE

CARMICHAEL, W. W. (ed.): The water environment: Algal toxins and health. Plenum Press, New York, London. 1981. 491 pp.

The papers of the international conference (International Conference on Toxic Algae) held in the University of Dayton (Wright State University, Dayton, Ohio) from June 29 to July 2, 1980 have been compiled in the form of a book by Plenum Press and give an account of the results of recent research. Although the lectures of a conference can never constitute such a closed unit as e.g. a handbook, the authors of the book nevertheless strove to give an overall picture of toxic algae, algatoxins.

According to the data of the literature certain *Cyanobacteria* species (*Cyanophyta* species according to the classical taxonomic classification): *Microcystis aeruginosa*, *Anabaena flos-aquae*, certain strains of *Aphanizomenon flos-aquae* caused intoxications in fresh waters. The green alga toxicity of a *Synechocystis* sp. (*Cyanobacteria*), the *Pandorina morum* which has not been finally identified yet are also discussed. When found in great quantities, the following species caused intoxication in the seas during algal bloom: *Lyngbya majuscula*, *Oscillatoria nigroviridis*, *Schizothrix calcicola*, *Cyanobacteria* species; *Exuviella marie-lebouriae*, *Goniaulax catenella*, *G. monilata*, *G. tamarensis*, *Gymnodinium breve* from *Dinoflagellates*; *Prymnesium parvum*, *Chrysophyta* sp. is found equally in brackish water and sea-water.

Of course, toxicity of the toxic algae and algatoxins are interpreted in the widest sense. Some species have a toxic effect on algae and bacteria while others, on microscopic, macroscopic aquatic animals, fishes, birds, mammals and on human beings.

Much remains to be done inspite of the numerous results which are important for public health. Mainly, because the accurate construction and toxicity of the algatoxins are often not known exactly. That is how CARMICHAEL writes about it in case of fresh water species, "Exotoxins are known to be produced by strains of at least three species of freshwater *Cyanobacteria*. These are *Anabaena flos-aquae*, *Mycrocystis aeruginosa* and *Aphanizomenon flos-aquae*. Of about 12 toxins produced by these species only one has been identified, synthetized and its toxicology determined. When waterblooms of these toxic species are present in a reservoir, lake, pond or slough, the cells and toxins can become concentrated enough to cause illness or death in almost any mammal, bird or fish which ingests enough of the toxic cells, or extracellular toxin. Major losses to animals include mainly cattle, sheep, hogs, birds (domestic an wild) and fishes while minor losses are reported for dogs, horses, small wild mammals, amphibians and invertebrates. Acute oral toxicity to humans has not been documented but there is increasing evidence that the toxins cause gastroenteritis and contact irritations in users of certain recreational and municipal water supplies. Lipopolysaccharide endotoxin is also produced by certain *Cyanobacteria* including *Schizothrix calcicola* and *Anabaena flos-aquae* and has been implicated in certain water-borne outbreaks of gastroenteritis among humans."

The volume comprises five large chapters. In the first (I. Review of Toxic Algae) four summarizing studies can be read about the toxic algae and their toxins living in fresh and salt-waters.

In the second chapter (II. Occurrence and ecology of toxic *Cyanobacteria*) eight studies deal with the toxic and non-toxic strains of the *Microcystis aeruginosa*, *Anabaena flos-aquae* and *Aphanizomenon flos-aquae*. Account is given of the waters and ecological conditions in and under which they have occurred and caused intoxications. It is described how light intensity influences their reproduction and the formation of their pigments and gasvacouloms during the laboratory growings. The formation of gasvacouloms is illustrated by TEM photographs. The toxic and non-toxic formations of the *Aphanizomenon flos-aquae* are subjected to detailed examination (SEM) carried out with light microscope and electromicroscope. The results seem to imply that toxic and non-toxic formations will be separable morphologically, too.

The third chapter comprises five articles (III. Culturing methods and reports of the new toxic species). The culturing methods of the *Cyanobacteria* are described in detail. More-

over, the physico-chemical factors exerting an influence in the axenic cultivation of *Microcystis aeruginosa* can be revealed. The toxic effect of a *Synechocystis* sp. and of the *Pandorina morum* is also presented.

In the fourth chapter five studies deal with the influences of toxic *Cyanobacteria* species on public health (IV. Public health and toxic *Cyanobacteria*). The ten articles of the fifth chapter deal with a problem scope, similar in many respects. (V. Isolation, physiology, toxicology and detection of *Cyanobacteria* toxins.) The titles of some articles of these latter two parts refer to a wide range of research relating to public health:

*Cyanobacteria* and endotoxins in drinking water supplies.

Effects of a hepatic toxin from the Cyanophyte *Microcystis aeruginosa.*

Chemical studies on toxins from the blue-green alga *Aphanizomenon flos-aquae.*

In addition to the detailed bibliography which every article ends with, a separate bibliography of the subject is given at the end of the volume (216 works). The volume ends with a list including of the contributors and with an subject index. Several studies are illustrated by TEM, SEM microphotographs which are perfect in typographical respects.

This collected work is, in many respects, a stop-gap and also pointing forward. It can be recommended rightly to researchers working in the field of botany, microbiology, hydrobiology, toxicology, ecology and also to practical experts.

K. T. Kiss

J. A. Duke: Handbook of Legumes of World Economic Importance. Plenum Press, New York, 1981, 345 pp.

This long-needed volume, which gives detailed but thorough information on 150 legumes of world economic importance, piecing the newest results of research together, reflects the authors' comprehensive special knowledge.

The plants — the members of *Mimosaceae*, *Caesalpinaceae* and *Fabaceae* families — are described in alphabetical order, according to their scientific names, with their more important synonyms and names in common use being given.

In the first chapter the general utilization of each plant is dealt with. In the following chapter special stress is laid on popular therapy, giving new information on the so far unexploited possibilities. The use of certain plants in cancer experiments is also referred to. In another chapter the chemical composition, the content of active agents and toxic substances of plants are described. Furthermore, an excellent, thorough description on plants is given with their most important taxonomic marks. In the chapter on germplast the important cultivars are listed, with their mentioned resistability and tolerance. The centres of origin and chromosome number are also given.

The chapter discussing the geographical range affords a good opportunity for comparing the present and chronological spread of the plant. In the chapter on ecology the data of optimal life space, annual precipitation and temperature, soil pH are listed. This is followed by questions of cultivation, plantation, pollination, intercrops, crop preservation providing assistance and inspiration for the grower. This can be used just as well in countries with mechanized agriculture as in the ones with conventional, non-mechanized agriculture. In the chapter on harvesting the methods and conditions of harvesting as well as the countries most suitable for the growing of the respective plant are mentioned. Data on the conventional crop capacity and the yield to be reached, including the biomass production, is invaluable. Finally, before listing the most important references relating to the plant, the pathogens and parasites in the different growing areas and the form of protection recommended are listed.

All the plants are wonderfully illustrated making the monography even more useful.

Seven good tables are included in the appendix, where the contents active agents of the plants, their ecosystematic attributes, tolerances, yields, centers of diversity and ecocenters are also included. The zero-moisture nutrional analysis and the amino-acid composition of various legumes are given in detailed table. The comparison of the individual plants is facilitated by the appendix.

This handbook may be of most benefit to growers and researchers.

G. Kósa

Clutter, M. E. (ed.): Dormancy and developmental arrest. Experimental analysis in plants and animals. Acad. Press, New York, 1978, 316 pp.

In this book the editor (M. E. Clutter) has collected the most interesting features in plants and animals, namely the forms of various manifestations of dormant states and develop-

mental arrests. These have occupied the minds of not only biologists but also other scientists, religious thinkers, philosophers etc. This motivated the calling of an AAAS symposium entitled "Mechanisms of Dormancy and Developmental Arrest" held in 1972. The book, however, throws light on the phenomena causal relationships, endogenous and exogenous factors, and regulatory mechanisms thereby revealing the mechanisms involved in dormancy and developmental arrest under experimental and field conditions.

Three chapters of the book are devoted to studying the variety of dormancy in animals, four to that in plants. The book is well illustrated and has a subject index.

Renfree, M. B. (Chapter 1) discusses the embryonic diapause characteristic of mammals which may be observed in the early developmental stages. A survey is given on the characteristics of diapause and the taxonomic groups of mammals in which these phenomena are found during their ontogenesis. The experiments on laboratory rodents are extended to include studies on three wild species centered on the blastocyst-uterine, and pituitary-ovarion interactions. The regulatory mechanisms determining the retardation of development (photoperiod, nutrition, endocrinological factors etc.) are discussed at depth focussing on the importance of the complex synchronization of endogenous and exogenous factors, too.

In the second chapter insect dormancy during the morpho- and ontogenesis has been studied by Jungreis, A. M. After clarification of several definitions insect dormancies the dormant stages induced by light, the dormancy maintenance and termination are discussed. The next section is concerned with the physiology of hibernal diapause in *Lepidoptera* including the various regulatory factors (such as cations, uric acid, trehalose, etc.).

V. Walbot in Chapter 3 is concerned with an experimental approach to the regulation of embryogeny in plant seeds. Three developmental programmes are distinguished that regulate developmental arrest. The difference between dormant, quiescent and viviparous embryos may be attributed to the timing of developmental changes. This hypothesis is supported by experimental evidence. The embryo development of various typical plant species is discussed in detail, characterizing the different stages and processes taking place during the development. A complete section is devoted to the regulating processes, both endogenous and exogenous controls. From reviewing the experimental evidence summarized in this chapter the author regards water relations in embryo development of major importance.

A whole chapter (Chapter 4) is concerned with the seed dormancy of wild oat. Studying the survival and dormancy of this plant species is a most intrinsic task because the wild oat is a vital weed in the temperate zone. G. M. Simpson applies an experimental approach to determine the nature of seed dormancy, the interactions between the seed and its environment. The problem may also be approached by systems analysis. The seed structure has an essential role in dormancy so the evidence for the role of seed parts is shown in detail. Furthermore certain essential environmental factors (light, temperature, water, gases) have a determining role in causing dormancy (both the primary and secondary ones), especially those environmental conditions which can induce secondary dormancy. After a brief review of the organic and inorganic compounds in the seed parts the seed — environment system is discussed by using the information of the previous sections in flow charts.

The fifth chapter deals with the dormancy of various types of buds in plants, especially in trees. The authors (L. D. Noodén–J. A. Weber) discuss in detail the metabolic processes underlying those genetic and environmental factors which control bud dormancy. The impact of certain environmental factors on dormancy — its development, maintenance and release in buds — is illustrated by several examples. As dormancy is a repressed or inhibited state and the dormant organs grow differently from the normal ones, it is worthwhile studying which growth inhibitors induce dormancy in buds, and then at the termination of the dormant state how the synthesis of growth promoters change.

Three forms of dormancy are generally distinguished in mammals and birds: sleep, shallow torpor and hybernation. These states are discussed in the sixth chapter (H. C. Heller–G. L. Florant–S. F. Glotzbach–J. M. Walker–P. J. Berger). They suppose that these different forms of dormancy are homologous adaptations that have evolved in response to selective pressures favoring energy conservations. So their examinations are focussed on comparative electrophysiological and thermoregulatory studies.

The brief seventh chapter (written by I. M. Sussex) is about the role dormancy has during plant development, and refers to the factors regulating dormancy which really may be regarded as an adaptive strategy.

The book first of all was written for specialists in this field.

E. Molnár

HICKEY, M.–KING, C.: 100 Families of Flowering Plants. Cambridge University Press, 1981, 567 pp.

Systematics biology for most people is extremely dull and to popularize it has always seemed to be one of the hardest tasks of experts and particularly when it is intended to reach a larger inquiring public. This collaboration by these authors from Cambridge has proved to be most worthwhile as indicated by their past works (CULLIS–DAVIS: The Identification of Flowering Plant Families. Recens.: Acta Bot. Acad. Sci. Hung. 26/1980). Their present book is a kind of enlarged lecture notes, which has been prepared mainly for senior students specializing in biology to carry out their botanical practical work with greater success and to broaden their knowledge. It is aimed to draw a distinction between the most important plant families on the basis of their characteristic features. The authors' method of distinguishing between the most important plant families, in accordance with the widespread practice is to introduce the chosen families accompanied by a detailed examination of a few characteristic types of species. According to Dr. WALTERS, S. M., Director of the Botanic Garden of Cambridge the particular value of this work compared to other similar ones, is that it allocates the relevant data scattered and hard to be found in the literature into one place, furthermore it draws the reader's attention to observe special features important from the point of view of systematization. In this way the whole methodology of comparison can be acquired with ease.

It was a difficult task for the authors to choose the sample plants out of many thousands of species of almost 400 families of plants so that the 100 families considered to be the most important ones should be represented by their one or two most typical species, the samples of which can be easily obtained at the same time. The authors wish to present the similarities and differences between the families through an analysis of these typical species and thus, after all, to reach their most important aim, namely that the characteristic distinctive features of the individual families should become clear to the reader. The constraints imposed by a work of this size and the number of typical species, however, enable only the most fundamental of these characteristics to be presented in spite of the fact that the authors evidently strove to attain a relative completeness. That is why major tropic families had to be left out (*Melastomataceae*, etc.). After a morphologic introduction accompanied by many figures a general characterization is given of the chosen families, their range, economical and ornamental importance, the names of the more important genera, then the system within the family is outlined, descending to subfamilies, tribes and main genera. Then the typical plant is analysed in detail, and a few characteristic features of some related species, which can be easily confounded with the typical plant, are also referred to. The study of each typical plant is facilitated by a series of figures of a whole page showing the flower structure in all its details, provided with separate comments on figures giving the actual size of the individual organ parts others.

It is a most comprehensive, work contributing towards an understanding of the most characteristic regularities and connections. Perhaps an insufficiency could be mentioned. The structure of the reproductive organs constitutes the basis of up-to-date systematization even today, hence these are shown almost exclusively in the published illustrations. The vegetative structure of the organ or a certain part of it, however, is very characteristic of more families and it is of the same importance, moreover, sometimes it is of exclusive taxonomical value (*Umbelliferae*, *Leguminosae*, leaf bases of *Gramineae*, etc.). In cases like these the illustrations, too, ought to have been enlarged accordingly. The text of the book is unnecessarily verbose and sometimes oversimplified (Page 2, paragraph: "A flower . . ."). The selection of the figures of the morphologic introduction seems to be rather arbitrary. Some important and frequent ones are left out of the forms of corolla. (Pages 4 and 5: papilionaceous flower, tubiferous flower of *Compositae*.) The indication and presentation of ligula as well as that of the similarly important auricula are not to be found in the figure showing the leaf sheath (p. 548). LINNÉ's classification of stamen seems to be out-of-date, though it can be accepted from a morphological respect and it is most suitable for teaching purposes (p. 9). Otherwise, such a large division of the illustrations of the same nature into two parts is unwarranted half of them is on pages 3 to 16, while the other half is on pages 544 to 553! It appears as if the authors wanted to present the plant world not exclusively from morphologic, physiologic or systematics viewpoints, but perhaps to achieve a certain complexity, which, according to my feeling, would require a longer and more explicit morphological introduction. In the preface (XV.) the authors refer to the CULLEN and DAWIS as the basic work used in their systematization. But it does not come to light whose system is followed by them. The taxonomical names and the bibliography lead us to believe that we face a kind of modified ENGLER system. (Cp. ENGLER's Syllabus 1964. 202 *Caesalpinioideae*, etc.) I suppose that, it would be premature to make the students familiar with the problems of taxonomic theory arising again nowadays.

Nevertheless, in the systematics of the families the systematists are referred to by name, hence the exposition of the taxonomic conception, which would become complete with the taxonomic table of the division of families to be found in the beginning of the book, would be necessary for this reason, too.

What seems to be most tacking is the mention of evolution in the text and illustrations, which otherwise are excellent. But if the increasingly evolutionary grounding of the public education of the last ten years is taken into consideration, this development must of necessity be demonstrated in botany, too, even if our present knowledge on the subject is fragmentary. In a special book devoted to up-to-date phylogenetic systematization one cannot ignore at least the main stages of development, especially, if we consider that the up-to-date systems are based just on the evolutionary value of the morphologic features. Most of the chosen families and typical plants serve their required purpose well. With great families it would have been useful for the considerable subfamilies, too, to be represented by a separate species, hereby the development within the family, could have been presented too. The short, brief characterizations, which are regrettably left out just at the *Compositae* tribes (p. 419), facilitating the separation of the taxons under the families, are excellent. In the deviating data of smaller taxons, the exclusiveness ought to have been indicated in some way or other, whereby the interpretation of the dispersions could be more exact and definite (e.g. at *Scilla* sp. the indication of three Far-Eastern species is left out; p. 492). The excellent and very detailed drawings of flower structure and the comments on them in themselves, stimulate a thorough examination and, complemented with the text, they provide a most ample material for acquisition of knowledge. It is a pity that the handling of the book is made cumbersome by the frequent changes of the place of the page numbers (18 to 22, 23 to 25). The 27 empty pages, which are numbered in spite of it (17, 37, 41, etc.), are not economical at all for by the utilization of these pages the above-mentioned enlargings could have been carried out without lengthening the book. The special botanic dictionary of 19 pages is very useful and it would have been of full scientific value if the Latin terms had been given, too. The short description of the formation of the Latin plural number is witty (p. 543). The 4 tables provide a comparison of the relative families which was the aim of the authors; they also facilitate the distinction between 3 very similar families each. More tables of this kind ought to have been constructed: *Chenopodiaceae–Amaranthaceae–Polygonaceae*; *Tiliaceae–Ulmaceae–Moraceae*; *Lythraceae–Thymeleaceae–Myrtaceae*, etc., in which the most important properties relating to the theory of evolution could have been accentuated by different type-setting. The table of the flowering period of the published typical plants is a good guide for the collection of the living plants. Family and genus indexes facilitate the availability of part information.

In my opinion, the chief value of this book can be found in its comprehensiveness, ranging over several branches of science and is in its compactness. The great efforts in our days to reach unity are well reflected in it. It is a basic yet synthetic work, serving also as methodological pattern to be followed. Hence, it can be of great help mainly to institutions dealing with botany at any level, as well as, to teachers of biology, moreover it would also be useful as a handbook for practical work. Every plant lover can find it rewarding, while experts may find it useful mainly in their preparatory and scientific work for the general public. The everwidening material of knowledge, newer scientific results, necessarily lead to the modification of the curriculum from time to time. It is essential how the new information reaches the reader. Hence every effort, endeavoring to form a uniform, thorough and comprehensive observation of nature by up-to-date means, accepting the concomitant slips in pioneering work, is most welcome.

Z. Kereszty

F. Weberling: Morphologie der Blüten und der Blütenstände. Eugen Ulmer Verlag, Stuttgart, 1981, 391 pp.

This is a new monography on the most fascinating subject of plant morphology, that of the reproductive organs, of mainly the flowers and inflorescences. The author is disciple of the classical school of plant morphology, that of Prof. W. Troll's, a successor and integrator of this particular discipline of German plant science, from the earliest date, 1790, when J. W. Goethe's "Attempt of explaining the metamorphose of plants" appeared. In the file of basic studies Eichler: "Blütendiagramme" and Goebel: "Organographie der Pflanzen" both dating from the end of the last century, several books of W. Troll give the main patterns, among others of his first monograph of 1928, and the "Practical introduction to plant morphology" part II, "The flowering plant" of 1957. Those works are not only historical precedents of this book, but also sources of ideas borrowed and continued in the present treatise.

Though admittedly, only a fraction of the ample selection of studies, nearly 800 of them, has been cited, it is claimed to be exhaustive in the systematic presentation of the subject. Surprisingly, most of the studies have appeared since the middle of this century, about 2/3 of the cited items, and an increasing proportion, more than 1/3, represents non German i.e. mainly English, French, American, etc. papers on plant morphology.

What could be the reason for this renewed international interest in descriptive plant morphology? Most likely, the claim of constructing taxonomical systems on a biological basis cannot ignore morphological arguments to follow up phases of ontogenetic processes, which in turn, give important premises to phylogenetic conclusions.

The volume is divided into three parts. The most voluminous (211 pages) presents the morphology of the flower. The second part (110 pages) is devoted to inflorescences, and only the small third part (33 pages) explains the morphological aspects of the function of the flower. Its morphology could be analysed and explained also from the point of view of mating systems and dispersion of seeds. This has relevance to application especially the characterization of pollination mechanisms, and at the end, dispersion mechanisms.

The last 10 pages thus deal with the fruits as structures of dispersion. Flower and fruit are ontogenically connected, but the latter, certainly, may deserve another, though less voluminous book. The third part, although short and not mentioned in the title considerably increases the value of this book.

As a monograph, the book is an attempt to present morphology theoretically. References to anatomy, flowering biology or to any practical implication are of secondary importance, except where those are reflected in morphological phenomena, e.g. in the structure of the inflorescence of wild and cultivated species and varieties of the genus *Ficus*. It is a morphology in a classical sense, the only way to attain a high degree of comprehension within the limits of one volume. Anatomy and flowering biology etc. are far less developed to be associated with each morphological structure this book.

There are many drawings of external appearance on growing apices and longitudinal sections as well as diagrams, in some cases scanning electronmicroscopic photographs and habitus pictures of excellent quality, supporting the theoretical aspects. The reader may thus recognize the continuity of the Troll school.

Less space has been given to the alternative theories of the origin of the flower, the polemic of Euanthium and Pseudanthium, occupying only one and a half pages, whereas special attention has been paid to the diagrammatic representations, moreover the whole Greco-Latin terminology for the description of branching, the flower parts, and their numerical and topological relations.

The reader accustomed to the school of morphology developed by Troll is able to appreciate the meticulous care given to the systematic presentation. The abundant Latin species names referred to as examples — difficult to recognize for those who are not experts in taxonomy of exotic plants — are listed at the end of the volume, whereas the German designations are combined with another Subject index. The latter includes also the proliferating terminology of the German morphological school.

This volume providing a good summary of information on a science having a rich tradition may be a useful guide for teachers, as well as, students and amateurs of descriptive botany. Moreover those interested in the applied disciplines of botany may find this work invaluable.

A. Andrásfalvy

CONTENTS

# ACTA BOTANICA

## АКТИВНОСТЬ ФОТОСИНТЕЗА НА РАЗНЫХ СТАДИЯХ ПЕСЧАНОЙ СУКЦЕССИИ

Г. ФЕКЕТЕ, З. ТУБА

Авторы измеряли активность фотосинтеза у видов, входящих в состав многолетного сообщества на карбонатных песках (*Festucetum vaginatae danubiale*) в трёх стадиях сукцессии. Доминирующий вид *Festuca vaginata* в пионерной стадии развития растительности характеризуется высокой активностью фотосинтеза. По мере прогрессирования сукцессии (смыкания дернины) эта интенсивность падала. Возможно, что причиной этого является разновозрастность особей, их старение. В ходе сукцессии уменьшается фотосинтетическая активность, приходящаяся на единицу площади ценоза. Точно так же уменьшается фотосинтетическая продукция, приходящаяся на единицу зелёной фитомассы. В этом плане различия между тремя участками являются сигнификантными.

## ХИМИЧЕСКИЙ СОСТАВ УЗКОЛИСТНОГО РОГОЗА *TYPHA ANGUSTIFOLIA* ОЗЕРА БАЛАТОН

МАРГИТ КОВАЧ

В береговой зоне озера Балатон под действием эутрофизации всё больше распространяется узколистный рогоз, вытесняя тем самым камыш. В разных органах рогоза (лист, стебель, корневище, корень, корненые волоски) определяли содержание **N, P, Ca, Mg, K, Na, Sr, Fe, Mn, Zn, Pb, Cu**, а также микро- и ультрамикроэлементов. Дифференция элементов в разных органах рогоза оказалась меньшей, чем у камыша.

Видовой особенностью узколистного рогоза является накопление **Na** и **Cl**, причём растение способно к большей аккумуляции этих элементов, чем *Phragmites communis*. Узколистный рогоз способен аккумулировать в больших количествах в первую очередь щелочные металлы (**K, Na**), щелочноземельные (**Ca, Mg, Sr**), а также **Cl** и **Zn**.

С помощью искровых масс-спектрографических исследований в разных органах рогоза обнаружено 34 микро- и ультрамикроэлемента.

В последние десятилетия по всей длине береговой зоны в северной части озера наблюдается два таких вида, которые способны аккумулировать щелочные е щелочноземельные металлы (***Stratiotes aloides, Typha angustifolia***). Превращение этих видов в массовые позволяет судить об изменениях, происходящих в среде Балатона (вода и донные отложения).

## КАТАЛОГ ПАЛЬМ КУБЫ

О. МУНИЗ, А. БОРХИДИ

Новый каталог пальм Кубы, учитывая результаты самых современных открытий и исследований, приводит 18 родов, 85 видов и 12 систематических единиц более низкого ранга. Авторы приводят таксоны по новой филогенетической системе (**H. E. Moore jr.**). с новыми определительными ключами и синонимами. Кроме этого, авторы приводят несколько новых таксонов, комбинации и статус: ***Hemithrinax*** **sect.** ***Macrocarpae*** **(León)**

**Muñiz stat. n., *Hemithrinax rivularis* var. *savannarum* (León) Muñiz comb. et stat. n., *Coccothrinax* sect. *Longispadiceae* (León) Muñiz stat. n., *Coccothrinax* subsect. *Multiramosae* (León) Muñiz stat. n., *Pauciramosae* (León) Muñiz stat. n., *Coccothrinax clarensis* ssp. *brevifolia* (León) Borhidi et Muñiz stat. n., *Coccothrinax* subsect. *Haitiella* (Bailey) Muñiz comb. et stat. n., *Copernicia* sect. *Ekmanianae* Muñiz sect. n., sect. *Albae* Borhidi et Muñiz sect. n., *Copernicia* subsect. *Fallaenses* Muñiz et Borhidi subsect. n., subsect. *Roigianae* Muñiz et Borhidi subsect. n., *Copernicia* × *Burretiana* (León) Muñiz et Borhidi stat. n., *Copernicia* × *occidentalis* (León) Muñiz et Borhidi stat. n., *Copernicia glabrescens* var. *ramosissima* (Burret) Muñiz et Borhidi comb. et stat. n., *Calyptronoma Clementis* ssp. *orientensis* Muñiz et Borhidi ssp. n.**

## ХАРАКТЕРИСТИКА РОСТА И БИОЛОГИИ ЦВЕТЕНИЯ ВИДОВ И КУЛЬТУРНЫХ СОРТОВ ЯБЛОНИ

Й. НЕКИ, А. ТЕРПО, М. ТОТ, Ф. ДЮРО, М. ШОЛТЕС

В 1977 году мы приступили к разработке «Системы опыления яблони». В 1977г. на 17, в 1978г. на 19 яблоневых деревьях изучали биологию цветения. Принимая во внимание время основного цветения и интенсивность одновременного цветения яблонь, изучамые растения разделили на 4 группы, согласно времени их цветения. Выявили виды яблонь, цветущих одновременно с промышленными сортами.

Несколько (не меньше $2^{-x}$) видов яблонь обнаруживает только гарантированное (выше 50%) перекрытие по времени цветения с промышленными сортами. Для интенсивных посадок можно использовать яблони, имеющие среднюю интенсивность роста и выгодный в этих условиях габитус.

## ВОСТОЧНОАФРИКАНСКИЕ МХИ, VI ПОЛЬСКИЕ СБОРЫ

Р. ОХИРА, Т. ПОЧ

В 1975—76 гг. члены Польской экспедиции в Восточную Африку собрали многочисленную коллекцию мхов на территории Кении, Танзании, Уганды, Судана и Центральноафриканской республики. К этой коллекции прибавились и другие польские сборы, в первую очередь из Замбии. Перечень мхов содержит 176 видов, из них 48 видов печеночных мхов и 128 видов листостебельных мхов со списком местонахождений, данными по экологии и географии мхов и замечаниями таксономического характера. Для восьми видов составлена подробная карта ареала. Многие виды являются новыми для территории сбора, а данные по ***Amblystegium serpens*** являются новыми для всей тропической Африки. Для известных в Африке видов ***Callicostella*** авторы указывают 29 новых комбинаций под родовым названием *Schizomitrium*. Другие новые названия: ***Schistidium perichaetiale* (P. Varde) Ochyra comb. nov.; *Schistidium cribrodontium* (Herz) Ochyra comb. nov.; *Homalothecium afro-striacum* (C. Müll.) Ochyra stat. et comb. nov.; *Kindbergia africana* (Herz.) Ochyra comb. nov.; *Kindbergia africana* var. *latifolia* (Demar. et Leroy) Ochyra comb. nov.; *Hypnum africanum* (P. Varde) Ochyra comb. nov. *Grimmia abyssinica* C. Müll.** оказалась синонимом ***G. apiculata.***

## ИЗМЕНЕНИЕ СОДЕРЖАНИЯ АЛКАЛОИДА В КУЛЬТУРЕ ТКАНЕЙ *DATURA INNOXIA* MILL. В ЗАВИСИМОСТИ ОТ УСЛОВИЙ КИЛЬТИВАЦИИ

Е. СЕКЕ, Г. ВЕРЗАР-ПЕТРИ, Н. Н. ДУНГ, А. ПОТОЦКИ

Авторы исследовали содержание алкалоида в каллусах различного происхождения (из корня, листа, венчика и завязи) в процессе культивации- паралельно с образованием биомассы. Было определено, что в первые две недели культивации содержание алкалоида было высоким, но в дальнейшем с интенсивным ростом тканей содержание алкалоида вновь повысилось. Авторы, исследуя влияние концентрации регулирующих рост веществ, определили, что высокая концентрация кинетина препятствует образованию алкалоида. Под влиянием 5мг/л 2,4-д образование алкалоида внезапно повышается. В каллусах корневого происхождения количество алкалоида достигло такой же величины как и в интактных корнях. Под влиянием света содержание алкалоида в каллусах корневого и листового происхождения было в два раза больше по сравнению с содержанием алкалоида в культурах, растущих в темноте.

## ПРОДУКТИВНОСТЬ И ТУРНОВЕР КСЕРОТЕРМОФИЛЬНХ ВИДОВ ЛИШАЙНИКА

Р. К. ВЕРШЕГИ

Автор изучал продуктивность всех лишайников на многолетних дернах ***Festucetum vaginatae*** и однолетних дернах ***Brometum tectorum***, а также продуктивность двух видов лишайника ***Cladonia furcata*** и ***C. magyarica*** преимущественно распостраненных на этих дернах, интенсивность и скорость обмена фитомассы лишайников и круговорот обмена минеральных веществ (**turnover rate** и **time**). Величины интенсивности и скорости на многолетнем дерне больше а в однолетнем меньше. В некоторых периодах (вегетационном и зимнем) на изменение фитомассы и на интенсивность минерального обмена веществ влияют не отдельные периоды года, а изменение факторов погоды. Период обмена фитомассы лишайников гораздо длиннее чем период обмена минеральных веществ.

## ИССЛЕДОВАНИЯ ДИНАМИКИ ВЫЗВАННОЙ ДЕЙСТВИЕМ ГЕРБИЦИДОВ СУКЦЕССИИ МНОГОЛЕТНЕГО ТРАВЯНИСТОГО СООБЩЕСТВА I

КЛАРА ВИРАГ

Это, имеющее вводный характер сообщение знакомит с предпосылками и планированием такого опыта, в ходе которого, воздействуя на однодольные и двудольные растения гербицидами селективного действия (габонил, далапон) и разного механизма общего действия (грамоксон, глиалка), вызываются быстрые динамико-вегетационные процессы.

В статье подробно анализируются цели научной программы. Исследования направлены, с одной стороны, на изучение структуры, меняющейся в ходе вызванной гербицидами сукцессии и деградации, с другой стороны, на выявление вызванных внешним воздействием динамико-вегетационных процессов и регулирующих их механизмов, а также на познание регенерационной способности травянистого сообщества ***Pulsatillo-Festucetum rupicolae***.

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